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A STRUCTURAL WEIGHT ESTIMATION PROGRAM (SWEEP) FOR AIRCRAFT. VOLUME VI - WING AND EMPENNAGE MODULE. BOOK 1: TECHNICAL DISCUSSION, SECTIONS I AND II

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Three computer programs were written with the objective of predicting the structural weight of aircraft through analytical methods. The first program, the structural weight estimation program (SWEEP), is a completely integrated program including routines for airloads, loads spectra, skin temperatures, material properties, flutter stiffness requirements, fatigue life, structural sizing, and for weight estimation of each of the major

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20. ABSTRACT (CONTINUED)

aircraft structural components. The program produces first-order weight estimates and indicates trends when parameters are varied. Fighters, bombers, and cargo aircraft can be analyzed by the program. The program operates within 100,000 octal units on the Control Data Corporation 6600 computer. Two stand-alone programs operating within 100,000 octal units were also developed to provide optional data sources for SWEEP. These include (1) the flexible airloads program to assess the effects of flexibility on lifting surface airloads, and (2) the flutter optimization program to optimize the stiffness distribution required for lifting surface flutter prevention.

The final report is composed of 11 volumes. This volume (volume VI) contains the methods and program description for the wing and empennage module of SWEEP. Program listings and flow charts are included in the appendix to this volume.

NOTICES

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Publication of this technical report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

JAMES H. HALL, Colonel, USAF
Deputy for Development Planning

PREFACE

This report was prepared by Rockwell International Corporation, Los Angeles Aircraft Division, Los Angeles, California, under Contract F33615-71-C-1922, No. FX2826-71-01876/C093. The work was performed for the Deputy for Development Planning, Air Force System Command, Wright-Patterson Air Force Base, Ohio, and extended from September 1971 to June 1974.

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The final report was published in 11 volumes; the complete list is as follows:

Volume

I "Executive Summary"
II "Program Integration and Data Management Module"
III "Airloads Estimation Module"
IV "Material Properties, Structure Temperature, Flutter, and Fatigue"
V "Air Induction System and Landing Gear Modules"
VI "Wing and Empennage Module"
VII "Fuselage Module"
VIII "Programmer's Manual"
IX "User's Manual"
X "Flutter Optimization Stand-Alone Program"
XI "Flexible Airloads Stand-Alone Program"

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INTRODUCTION TO VOLUME VI

The structural weight estimation program (SWEEP) has been developed as an analytical aircraft structural weight prediction tool suitable for use in the preliminary design phase of vehicle synthesis. Structure weight estimates for the three lifting surface components of any aircraft design are made by the wing and empennage module of SWEEP. This volume describes the procedures and internal operations of the module for:

- Structure and mass properties estimation of wing, horizontal tail, and vertical tail surfaces.
- Interface with the control and data development modules of SWEEP.
- Optional analysis of primary structures designed with metallic or advanced composite materials.
- Optional analysis and output of design data for use by the stand-alone flutter optimization and flexible airloads programs.

Volume VI is organized into eight separate books:

- Books 1 through 3 contain technical information describing the module, methods used, and the applicable module core maps.
- Books 4 through 8 contain Appendixes A through F, which include program flow charts and listings for the eight major segments of the module.

BOOK 1

TECHNICAL DISCUSSION, SECTIONS I AND II

Section I

MODULE DESCRIPTION

The wing and empennage module of SWEEP develops structure weight and mass distribution estimates for wing, horizontal tail, and vertical tail surfaces. The procedure used is designed to analytically evaluate the effects important to design parameters such as air vehicle design criteria, surface geometry and structural arrangements, materials and constructions, etc. This is accomplished through a close approximation design and analysis procedures programmed to describe detail surface geometry properties and structural design requirements. These are used to synthesize structural geometries and material requirements so that analysis for weights and mass distributions can be made.

GENERAL DESCRIPTION

The module consists of routines in level (8,0), (9,0), (10,0), (14,0), (15,0), (16,0), (17,0), and (18,0) overlays of SWEEP. It is executed once for each surface analyzed during a problem case. Design data are processed into component data arrays for the module in accordance with design requirements for surface type and analysis control information on case control card 2. Logic is programmed to permit module execution for each component analysis in stand-alone mode or integrated with other SWEEP analysis modules.

In the stand-alone mode, all design data are input through the input data decks for the surfaces. The module is executed in conjunction with the input data processing module in SWEEP, overlay (1,0), and the output module, overlay (13,0). In the integrated mode of operation, analysis data are computed by SWEEP design data development modules. The data are transmitted to the wing and empennage module through mass storage file records to be processed and used in accordance to control and analysis information in the input data decks for the component.

The wing and empennage module consists of major subroutine groupings designed to perform computational functions related to:

1. Module input data processing of problem design information from component input data decks, SWEEP data bank, and mass storage file records containing criteria and design information developed by other SWEEP modules.

2. Surface geometry calculation to define and locate all structural components of the surface.

3. Surface design requirements calculations to define parameters such as design airloads, required flutter stiffness, material properties, and deadweight inertia loads.

4. Structural synthesis of surface torque-box structures and, if required, pivot structures of variable-sweep wing designs.

5. Detail weight estimates for each element of the torque-box and statistically derived weight estimates for the other major structural components of the surface. Mass characteristics are determined for all structures so that estimates can be made for weight distributions, centroids, and inertias.

6. Module processing of analysis results for the OUTPUT module of SWEEP and for output printing of pertinent data.

The eight overlays of the wing and empennage module are logically controlled by SWEEP control program ØLAY00, overlay (0,0). The logical order of their execution and primary computational functions are shown in Figure 1. The module contains 109 separate subprograms, including the eight overlay programs. Nineteen of the subroutines are used in two or more overlays. Table 1 contains an alphabetical listing for all 128 subroutines found in the eight module overlays.

All problem data for analysis control and/or input of variables to each of these parts can be made through the input data deck. Module logic is programmed so that variables input through the input data deck supersede design data stored on mass storage files. Each component input data array is initialized from data blocks of the SWEEP data bank. Except for differences in weight correlation factors, the initial values for each surface are identical. Material properties for metallic structure analysis are obtained from from the material library of the data bank. Airfoil and flutter analysis constants for T-tail vertical tails are also obtained, as required, from data sets in the data bank.

Lifting surface designs with unique configuration and physical arrangements which can be analyzed include:

- Variable-sweep wings for which pivot structures and effect of sweep position are evaluated in the loads and flutter requirement analysis.

- Vertical tails in a T-tail arrangement for which horizontal tail effects on vertical tail design loads and flutter requirements are evaluated.

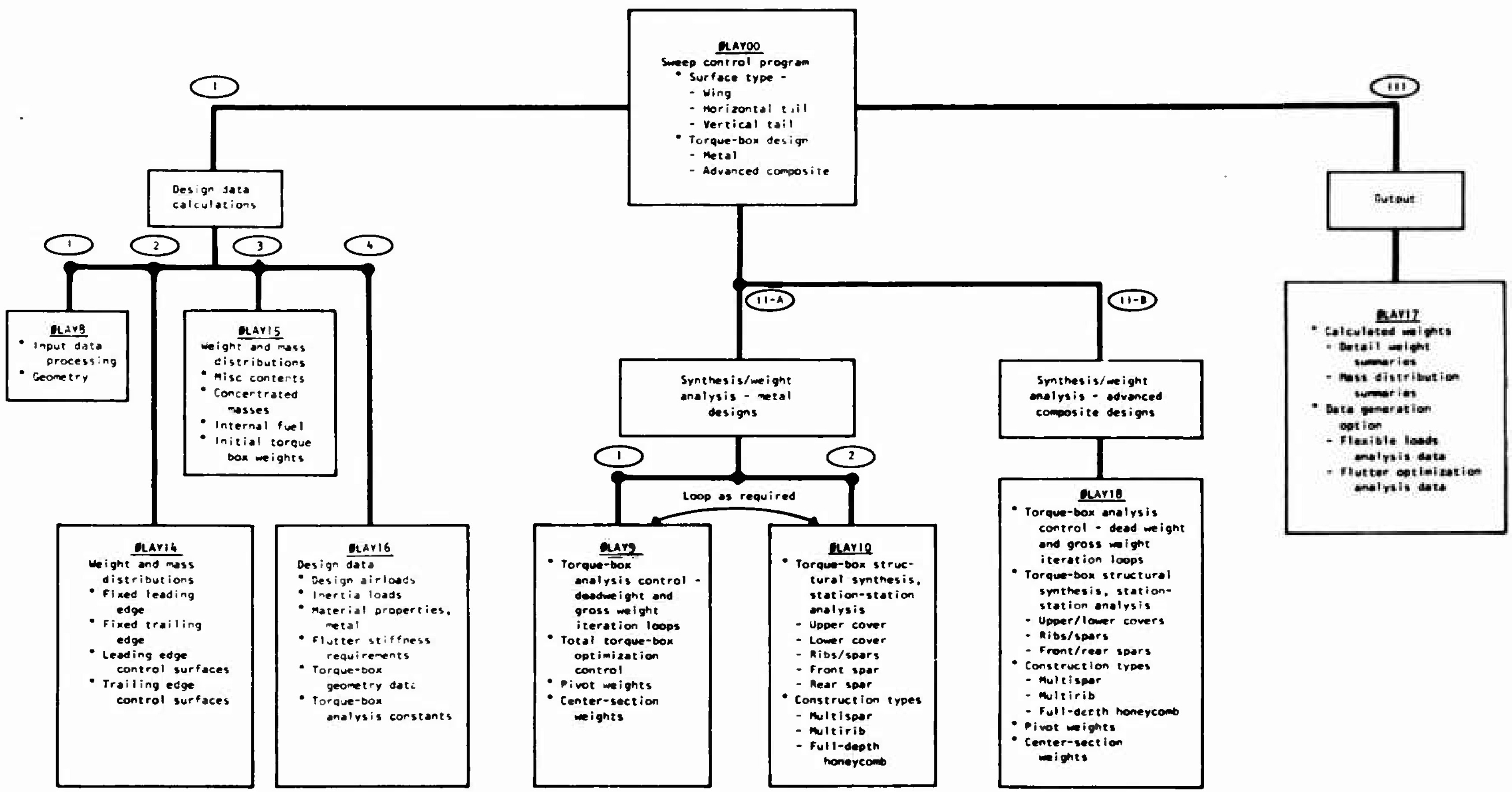


Figure 1. Wing and empennage module, overlay execution flow diagram.

TABLE 1. SUBPROGRAM LIST, WING AND EMPENNAGE MODULE

DECK NAME	OVLAY	- . - . - DESCRIPTION - . - . - . - . - . - . - . -
ABDW	16	INITIAL STRUCTURE AND CONTENT INERTIA LOAD SETUP
ABOXC	08	TORQUE-BOX CROSS-SECTIONAL AREA INTEGRATION
ACEIGJ	18	TORQUE-BOX EI/GJ EVALUATION - ADV. COMP. ANALYSIS
ACLOAD	18	DESIGN LOAD DATA PROCESS - ADV. COMP. ANALYSIS
ACMRSK	18	SKIN-STR LOAD DIST, SKIN STABILITY -ADV.COMP.ANALYSIS
ACNSTR	18	SECTION DESIGN DATA/WT ANALYSIS CONTROL - ADV. COMP.
ACPROG	18	TOTAL SURFACE WEIGHT SYNTHESIS CONTROL - ADV. COMP.
ACPRTA	18	DESIGN DATA PRINT-TYPE A TORQUE-BOX SYNTHESIS SUMMARY
ACSTRG	18	STRINGER GEOMETRY/SECTION PROPERTIES-ADV.COMP.ANALYSIS
ACWFCH	18	FULL DEPTH HC SECTION OPTIMIZATION - ADV.COMP.ANALYSIS
ACWMS	18	M/SPAR, FDH TORQUE-BOX SYNTHESIS - ADV.COMP.ANALYSIS
ACWRBS	18	M/RIB TORQUE-BOX SYNTHESIS - ADV. COMP. ANALYSIS
ACWSTR	18	SKIN-STR/RIB SECTION OPTIMIZATION - ADV.COMP.ANALYSIS
ALOAD	16	DESIGN AIRLOAD PROCESSING
ASTIFF	18	TORQUE-BOXSTIFFNESS EVALUATION - ADV.COMP.ANALYSIS
ATBOPT	18	ADV. COMP. TORQUE-BOX SYNTHESIS CONTROL
AVLOAD	18	NET ULT. LOADS CALC. - ADV. COMP. ANALYSIS
BHDJT	10	BULKHEAD AND JOINT WEIGHT EVALUATION
BHDJT	18	BULKHEAD AND JOINT WEIGHT EVALUATION
BOT	10	INTERPOLATION/EVALUATION FOR FC OR B/T
BOTC	10	PLATE BUCKLING B/T EVALUATION
CAERC	06	TRAPEZOIDAL/TOTAL PLANFORM CHORD EVALUATION
CASE	08	GENERAL DATA INITIALIZATION AND CONTROL
CCNTL	08	INITALIZATION - DATA TRANSFER FROM GENERAL DATA
CDL	15	EXTERNAL CONCENTRATED DEADWEIGHT EVALUATION
CG3P	10	PARABOLIC CURVE FIT AND EVALUATION
CKSFDH	18	STABILITY CHECK FOR FULL DEPTH HC CORE -ADV.COMP.SKINS
CKSTAB	18	COMP/SHEAR STABILITY CHECK FOR ADV. COMP. PANELS
CNSTC	16	STRUCTURAL SYNTHESIS CONSTANTS AND DATA SETUP
CNSTR	10	TORQUE-BOX SYNTHESIS/WEIGHT ANALYSIS CONTROL
CSECW	09	CENTER-SECTION WEIGHT EVALUATION
CSECW	16	CENTER-SECTION WEIGHT EVALUATION
CTOT	17	PLANFORM CHORD EVALUATION
CTOT1	14	PLANFORM CHORD EVALUATION
CTOT2	15	PLANFORM CHORD EVALUATION

TABLE 1. SUBPROGRAM LIST, WING AND EMPENNAGE MODULE (CONT)

DECK NAME	OLAY	DESCRIPTION
DEALW	09	CURRENT TORQUE-BOX INERTIA LOAD EVALUATION
DEADW	18	CURRENT TORQUE-BOX INERTIA LOAD EVALUATION
DLPVT	09	EVALUATION OF BOX STRUCTURE REPLACED BY PIVOT
DLPVT	18	EVALUATION OF BOX STRUCTURE REPLACED BY PIVOT
DMAX	08	AIRFOIL DEPTH EVALUATION
DWYLA	09	DEADWEIGHT/COUPLE ARM ADJUSTMENT FOR PASS I&I
DWYLA	18	DEADWEIGHT/COUPLE ARM ADJUSTMENT FOR PASS I&I
EIGJC	11	SECTION EI AND GJ STIFFNESS EVALUATION
FDIS	15	FUEL WEIGHT/DIST AND INITIAL T-BOX WT. EVALUATION
GCNTL	14	TORQUE-BOX, LE, TE GEOMETRY DATA SETUP FOR WT ANALYSIS
GCOMP	08	WING,H,V GEOMETRY DATA PROCESSING FOR OUTPUT
GEOMC	08	GENERAL PLANFORM GEOMETRY AND T/C DATA SETUP
GEOMW	08	WING,H,V GEOMETRY EVALUATION AND CONTROL
GJCAL	16	FLUTTER GJ REQD CONTROL AND EVALUATION
GJSI	16	FLUTTER GJ REQD CALCULATION AT STATION I
GJTT	16	FLUTTER GJ REQUIRED FOR T TAILS
LETEI	14	LE/TE WEIGHT INTEGRATION
LEWT	14	LE WEIGHT AND DISTRIBUTION EVALUATION
MISCIT	15	MISC CONTENT WEIGHT INTEGRATION
MISCNT	15	MISC CONTENT WEIGHT/DISTRIBUTION EVAL/CONTROL
MTLCW	16	MATERIAL PROPERTY PROCESSING CONTROL
MTLFW	16	MATERIAL PROPERTY CURVE FIT
MTLPW	16	MATERIAL PROPERTY DATA PRINT
OLAY8	08	PROGRAM FOR FIRST OVERLAY OF WING-EMPENNAGE MODULE
OLAY9	09	PROGRAM FOR FIFTH OVERLAY OF WING-EMPENNAGE MODULE
OLAY10	10	PROGRAM FOR SIXTH OVERLAY OF WING-EMPENNAGE MODULE
OLAY14	14	PROGRAM FOR SECOND OVERLAY OF WING-EMPENNAGE MODULE
OLAY15	15	PROGRAM FOR THIRD OVERLAY OF WING-EMPENNAGE MODULE
OLAY16	16	PROGRAM FOR FOURTH OVERLAY OF WING-EMPENNAGE MODULE
OLAY17	17	PROGRAM FOR SEVENTH OVERLAY OF WING-EMPENNAGE MODULE
OLAY18	18	PROGRAM FOR EIGHTH OVERLAY OF WING-EMPENNAGE MODULE

TABLE 1. SUBPROGRAM LIST, WING AND EMPENNAGE MODULE (CONT)

DECK NAME	OVLAY	- . - . - DESCRIPTION - . - . - . - . - . - . - . -
FINTU	17	MASS/DESIGN DATA PUNCH/PRINT FOR FLUT. OPT. PROGRAM
FIVUT	05	WING PIVOT SYNTHESIS AND WEIGHT EVALUATION
PIVUT	18	WING PIVOT SYNTHESIS AND WEIGHT EVALUATION
PROG	09	TOTAL SURFACE WEIGHT SYNTHESIS CONTROL
PRTA	09	DESIGN DATA PRINT-TYPE A TORQUE-BOX SYNTHESIS SUMMARY
PRTB	10	DESIGN DATA PRINT-TYPE B SECTION DESIGN DETAIL SUMMARY
PRTB	18	DESIGN DATA PRINT-TYPE B SECTION DESIGN DETAIL SUMMARY
PRTBR	10	DESIGN DATA PRINT-DETAIL SYNTHESIS SEARCH DATA
PRTC	1[illegible]	DESIGN DATA PRINT-TYPE C SECTION DESIGN DETAIL SUMMARY
PRTC	18	DESIGN DATA PRINT-TYPE C SECTION DESIGN DETAIL SUMMARY
PRTD	17	WING,H,V WEIGHT SUMMARY PRINT
PRTG	08	WING,H,V GEOMETRY DATA PRINT
PRTH	09	DESIGN DATA PRINT-TYPE H C-SEC/PIVOT DESIGN SUMMARY
PRTH	18	DESIGN DATA PRINT-TYPE H C-SEC/PIVOT DESIGN SUMMARY
PRTM	15	DESIGN DATA PRINT - MISC. CONTENT MASS DATA
RTRIB	1[illegible]	ROOT RIB AND SHEAR TIE WEIGHT EVALUATION
RTRIB	18	ROOT RIB AND SHEAR TIE WEIGHT EVALUATION
SECTD	10	TORQUE-BOX SECTION SYNTHESIS-SEARCH LEVEL 1 CONTROL
SESCH	10	SEARCH LEVEL 2 CONTROL--DESIGN STRESS
SKWEB	10	SPAR WEB CRITICAL STRESS EVALUATION
SKRIB	10	RIB T-WEB EVALUATION
SS	10	STRESS-STRAIN CURVE EVALUATION AT GIVEN STRESS
SS2	1[illegible]	STRESS-STRAIN CURVE EVALUATION AT GIVEN STRESS
STBAR	10	TOTAL COVER/SUPT STRUCTURE T-BAR EVALUATION
STRG	10	STRINGER/CAP OPT MATL DIST/GEOMTRY EVALUATION
STRGU	10	STRINGER/CAP GEOMETRY/BOUNDARY INITIALIZATION
STRIB	10	RIB T-BAR SYNTHESIS AND CONTROL
STRIL	10	STRINGER COLUMN LENGTH EVALUATION
STWEB	10	FRONT/REAR SPAR CAP/WEB EVALUATION AND CONTROL
SWPXYP	08	EVALUATION OF X,Y COORD. OF ROTATED POINT

TABLE 1. SUBPROGRAM LIST, WING AND EMPENNAGE MODULE (CONCL)

DECK NAME	OLAY	- . - . - DESCRIPTION - . - . - . - . - . - . - . -
TBFWI	17	FUEL/TORQUE-BOX WEIGHT INTEGRATION
TBFWII	15	FUEL/TORQUE-BOX WEIGHT INTEGRATION
TBOPT	09	TOTAL TORQUE-BOX WEIGHT OPTIMIZATION CONTROL
TBWDC	08	TORQUE-BOX SECTION GEOMETRY EVALUATION
TEDEV	14	TRAILING EDGE DEVICE WEIGHT ESTIMATION
TEE	09	PIVOT DESIGN/SYNTHESIS DATA EVALUATION
TEE	18	PIVOT DESIGN/SYNTHESIS DATA EVALUATION
TEL	09	PIVOT DESIGN/SYNTHESIS DATA EVALUATION
TEL	18	PIVOT DESIGN/SYNTHESIS DATA EVALUATION
TEMPC	16	MATERIAL PROPERTIES EVAL FOR ADV. COMP. ANALYSIS
TEWT	14	TE WEIGHT/DISTRIBUTION EVALUATION AND CONTROL
TEWTI	14	TE DEVICE WEIGHT/DISTRIBUTION EVALUATION
TPINT	17	PARABOLIC CURVE FIT AND EVALUATION
TSCH	10	SEARCH LEVEL 3 CONTROL--OPTIMUM T=SKIN</A=STR,CAP<
VFCAL	10	SECTION TORSIONAL STIFFNESS REQMT EVALUATION
VLOAD	09	ULTIMATE NET DESIGN LOADS PROCESSING
VLOADI	16	ULTIMATE NET DESIGN LOADS PROCESSING
VSGEOM	08	ROTATED SURFACE PLANFORM GEOMETRY EVALUATION
WCONT	15	CONTROL FOR WEIGHT ESTIMATION OF CONTENTS
WDDATA	16	DESIGN DATA GENERATION CONTROL
WEIGH1	18	SECTION WT/INCH FOR ADV. COMP M/SPAR, FOR TORQUE-BOX
WEIGH2	18	SECTION WT/INCH FOR ADV. COMP. M/RIB TORQUE-BOX
WFLDD	17	MASS/DESIGN DATA CALC/OUTPUT FOR FLEX LOADS PROGRAM
WLETE	14	LEADING EDGE - TRAILING EDGE WEIGHT ESTIMATION CONTROL
WODATA	17	WING,H,V ANALYSIS OUTPUT DATA CONTROL
WTCAL	10	SECTION/PANEL WEIGHT EVALUATION AND CONTROL
WTCAL	18	SECTION/PANEL WEIGHT EVALUATION AND CONTROL
WTPIN	10	SECTION WEIGHT/INCH EVALUATION
WTPIN	18	SECTION WEIGHT/INCH EVALUATION
WVFDD	17	MASS/DESIGN DATA CALC. FOR FLUTTER OPT. PROGRAM
XN	18	EVALUATION OF NO. OF N-PLIES FOR GIVEN L,M PLIES
YBSET	16	EFFECTIVE BOX DEPTH INITIALIZATION

- Nonlinear surface planforms due to leading edge blending and cranked trailing edges.
- Nonlinear torque-box cross sections due to nonlinear true aerodynamic chords and/or variable-thickness ratios (t/c) along the exposed span.
- Leading and trailing edge control surface arrangements.

These design features are described by input of specific sets of data. Module analysis is controlled by input control data associated with the data set. Internal logic assumes no evaluation to be made for these features in the absence of the control data and associated data sets.

The primary option for torque-box structure evaluation is the analysis of designs with either metallic or advanced composite materials. The default analysis is metallic design which is made by execution of overlays (9,0) and (10,0) in conjunction with overlays (8,0), (14,0), (15,0), (16,0), and (17,0). These overlays can be operated under SWEEP core requirements of 50,000 octal cell locations on the CDC 6600 computer. Advanced composite torque-box designs are analyzed by execution of overlay (18,0) instead of (9,0) and (10,0). This overlay, plus the other module overlays previously listed, must be operated under core requirements of 100,000 octal cells. Execution of the metallic or advanced composite overlays is dictated by control information in columns 39 through 44 of case control card 2 and assumes that compatible design information is provided in the appropriate locations of the input data deck. The advanced composite analysis is based on evaluation of lamina requirements for a balanced, symmetric laminate system consisting of required plies with fibers oriented 0°, $\pm 45^{\circ}$, and 90° to the direction of applied axial loads.

The structural synthesis/weight analysis for both metallic and advanced composite designs is programmed using similar optimization and evaluation procedures. Synthesis and search options are provided so that torque-box designs can be optimized or evaluated to specified structural arrangements and constraints.

A special option of the wing and empennage module permits the output of design and mass distribution data on punch cards for use as input data to the Flutter Optimization Program and the Flexible Loads Analysis Program. These programs are independent stand-alone programs also developed under this contract and are described in Volumes X and XI, respectively. Descriptions of input and output data for this option can be found in the discussions under "Analysis Options," of this section.

The program is structured to evaluate weights for up to three assumed gross weights during one case in the stand-alone mode. In the integrated mode of operation, only the second gross weight loop is executed. The three-gross weight loop allows the user to determine weight trends for predetermined

vehicle weight values. Airloads are scaled by the ratios of design gross weights. Logic is programmed also to develop torque-box weight trends in a single case by using the data set in locations 1301 through 1322 to input three sets of design parameter values to be used in the respective gross weight loops. The parameters which are specified include:

1. Minimum and maximum rib spacings

2. Minimum and maximum stringer heights

3. Minimum and maximum stringer spacings

4. Number of stringers

Three constant gross weight values should be specified for this situation so that the gross design airloads will be the same. Although the parameter data set is set up for multirib designs, multispar construction can be evaluated by inputting appropriate data with the data set.

Leading and trailing edge structures, tips, and external store provision weights are assumed to be constant for all three gross weights. Input data in locations 80 through 101 are used to describe the three gross weights. The data set in locations 159 through 174 are used to input fuel and external store loading requirements for the gross weights.

Design results for gross weight No. 2 are used to develop the design and mass properties output data sets for the Flutter Optimization Program and the Flexible Loads Analysis Program.

The weight summary data output from the module include estimated data for all three gross weights, if analyzed. Weights for the major surface components are tabulated, along with details for the torque-box structural elements and the components in the leading and trailing edges.

Module output is printed under control of information found in columns 3 through 38 of case control card 1. Three general types of analysis results are printed as output data; samples of each can be found in Appendix A of Volume XI. The first type includes analysis summaries printed at the conclusion of each analysis. The second type includes analysis details and array dumps used to supplement the summary outputs. The third type of module output is intermediate dumps of selected data during the structural synthesis search for the torque-box, printed under control of case control card 1 and data locations 574 through 578 of the input data array. All module data are printed under control of one control card in each case setup; therefore, output from module execution for each surface analyzed will be identical.

The major output summaries for design data computed during the various analysis phases of the module are as follows. Associated print control locations on case control card 1, necessary to order these printed outputs, are also included.

- Detail torque-box weight and coefficient summaries, column 37
- Planform and cross-section geometry data, column 6
- Leading and trailing edge structure weight and distribution summaries, column 12
- Fuel distribution summary, column 18
- Flutter analysis summary, column 22
- Material properties, metallic and advanced composites, column 19
- Airloads summaries, columns 19 and 20
- Initial 1 g intertia loads estimates, column 21
- Design loads and deadweight adjustment summaries, columns 24 and 25
- Design synthesis and weight distribution summaries, column 28
- Total surface calculated inertia summary, column 36
- Surface structure component and contents calculated mass distribution data arrays, column 38

ANALYSIS DESCRIPTION

The wing and empennage module analysis treats lifting surfaces as long, slender cantilever beams resisting shears and moments through a system of covers and supporting structures. The wing planform is described by a system of lines developed by the program from required input data. These lines describe the positions of the leading edge, trailing edge, torque-box limits, load reference axis, and synthesis cuts. Pertinent geometric coordinates can be specified, as required, to describe the torque-box shape, fuel cell locations, location and geometry of control surface devices, location of internal concentrated and distributed masses, and locations of externally mounted stores or nacelles.

The analysis consists of synthesizing and evaluation of structural requirements at all analysis control stations on the exposed panel. The first station defines the inboard end of the surface torque-box and the outboard end of the center-section panel, while the eleventh station defines the outboard end of the torque-box and the location of the surface tip structure. Locations of the control stations can be specified by the user; if not specified, the program assumes 11 equally spaced stations. The 10 structural panels bounded by the analysis control stations plus the tip structure make up the surface outer panel. Each panel consists of torque-box structure fixed leading and trailing edge structures, individual control surface structures (if applicable), structural fittings for externally mounted stores as required, and secondary structures. The complete surface consists of the outer panel, center section, and pivot structures, if applicable.

A combination of analytical and empirical methods is used to estimate the torque-box weight. A three-dimensional approximation of the main box structure is modeled from planform geometry and airfoil parameters so that cover and support structure weights can be synthesized to satisfy the imposed constraints of vehicle criteria and design. The synthesis technique considers design criteria and loadings, physical geometry, material properties, types of construction, fabrication, and design constraints in the development of structural sections.

Leading edge, tailing edge, tip, and secondary structural component weights are computed from program-derived geometric data, statistical data, and vehicle environment data. Provisions are made in the weight evaluation routines for leading and trailing edge structures to process up to three leading edge devices and six trailing edge devices. Input data sets are provided for each device so that internal calculations can be made to define types, sizes, locations, and weight distribution surfaces for mass properties evaluation. Leading edge structures are assumed to include all components forward of the torque-box front spar, consisting of fixed structures and control surface devices - slats, kruger flaps, or droop leading edge. Type code numbers are used to specify the device to be used with each of the three input data sets. Trailing edge structure are assumed to include all structures aft of the rear spar. Two spoiler and four flap-type devices can be specified through input data sets. The fourth flap-type set is processed as a special data set used to specify ailerons, elevators, or rudder surfaces, as well as flaps. Four flap configurations may be specified. These are plain, single-slotted, double-slotted, and triple-slotted flaps. Each flap-type device may be positioned anywhere along the span, with the panel leading edge anywhere aft of the rear spar. Spoilers may be placed forward of flap structures.

The leading and trailing edge mass properties estimation procedure initially describes an all-fixed structure distribution surface. As control surface devices are identified and positioned, weight distribution surfaces

for the devices are estimated and adjustments made to the fixed structure surface by appropriate deletions or reductions of ordinate values in the region where the devices are positioned. Weight distribution surfaces are identified for each component and are processed individually.

The tip is assumed to include all structures between the eleventh torque-box structural control station and the theoretical tip station. The 0- and 100-percent chord element lines define the fore and aft boundaries. Secondary structure weights are estimated as a fraction of the total outer panel weight. The weight fraction value may be changed by the user. Weights for structural attachment provisions are estimated for each of the seven concentrated mass items that may be located on the surface. The estimates are based on type of attach, weight of the mass item, and maximum vehicle maneuver load factor, N_z.

Inertia loads are determined at each control station by summation of 1 g shears and moments for structural components, contents, and concentrated mass items. Numerical integration methods are used for estimation of shears and moments from mass distribution surfaces defined for the 10 structural strips plus the tip. Each strip consists of leading edge, torque-box, and trailing edge panels which are divided into rectangular grids by equally spaced chordwise and spanwise lines. Grid geometry and mass distribution surface definitions permit evaluation of mass characteristics of each item within the panel. These are numerically integrated to control stations defined on the structural reference axis to produce estimates for strip mass inertia, weights, and moments. Structure components, contents, and concentrated mass items are evaluated separately so that the results can be processed into inertia loads and mass inertia data compatible with vehicle loadings at flight design points. Grid size for each of the strip panels can be controlled by the user with the control data set in locations 1143 through 1154 of the input data array.

Design airloads, shears, and moments in the structural reference system must be specified at each of the 11 structural analysis stations. The metallic analysis is limited to evaluation of two loading conditions defining critical up-bending and down-bending loads. The advanced composite analysis can evaluate up to 20 different loading conditions. Design loads can be input at each station, either through the component input data deck or by use of special input deck WHV LOADS. Loads inputted through the component input data deck will always be used, even if loads data on mass storage records are available through execution of the airloads module or input through the WHV LOADS deck.

Net design loads at each section are calculated by combining the inertia effects of the torque box, leading and trailing edge fixed structures, leading and trailing edge devices, fuel and fuel system, internally distributed mass items, and externally mounted mass items with the gross airloads values.

Control data in the input data deck locations 159 through 174 are used to specify wing fuel cell levels and external store status at the assumed design conditions. These specifications allow for computations of total inertia loading effects compatible with the gross airloads. The net loads are resolved into average cover loadings, N_x, and spar shear flow, q, for evaluation of structural material requirements.

In the determination of design loads, initial estimates are made for the unknown torque-box structure weights and distributions. The total weight value may be input or computed by the program as a fraction of the basic flight design weight. The distributed weights are replaced with computed values after each synthesis/weight analysis pass. Iteration logic is used to reduce discrepancies between assumed and calculated values. In the programmed procedures, adjustments are made for the next weight and distribution sets, to account for changes in cover load intensities due to the effects of changes in both design loads and section couple arms. Up to four iteration passes can be specified using location 369 of the input data array.

Structural stiffness requirements to prevent surface flutter are evaluated by a special analysis routine. A semiempirical method is used to estimate initial values of required torsional stiffness, GJ, at each station. Procedures are programmed for analysis of fixed surfaces, variable-sweep surfaces, and T-Tail verticals. The techniques used were developed for use in lieu of detailed flutter analysis. Analysis logic allows for bypassing the evaluation routines with user inputs of required stiffness requirement data in locations 346 through 356 of the input data array. The value in location 251, flutter analysis control word, must be specified as 2.0 with these inputs.

Available section stiffness reflected in the synthesized torque-box structure is computed and compared with required values. Thicknesses for the four torque-box webs – upper skin, lower skin, front spar, and rear spar – are increased as required at sections with inadequate stiffness levels. The adjustment procedure is designed to process the webs in the ascending order of their strength gage thicknesses, making adjustments to applicable elements only to meet the given stiffness levels. The thickness increase and identification data for affected webs are saved for later processing by weight analysis and output print routines.

For metallic structures, section stiffnesses are evaluated in terms of section J, assuming that material modulus of rigidity, G, is constant. In the section stiffness calculations for advanced composite structures, the evaluation accounts for the different values of G contributed by each web. The value of G for each web laminate is based on the number, stiffness characteristics, and orientations of the constituent plies.

Metallic torque-box structures can be synthesized for either stiffened skin multirib or plate multispar designs. The stiffened skin multirib design options are riveted Z, integral Z, integral I, and riveted angle. Plate and honeycomb panel cover designs are evaluated for multispar constructions. Advanced composite designs can be evaluated for stiffened skin multirib, plate multispar, and full-depth honeycomb sandwich constructions. Cover stiffener configurations for multirib constructions include integral I, Z, T, and hat concepts. Multispar options include single-plate or honeycomb panel covers.

Cover synthesis for stiffened skin multirib construction is based on determining practical cover geometrics that satisfy (1) stress conditions for strength, local stability, or general stability, and (2) constraints of specified minimum gages and stringer geometries. The effective cover material resulting at any specified operating stress level during the analysis is distributed into skin and stringer material. Stringer material is further distributed to satisfy stability and minimum gage conditions, resulting in stringer geometries of height, flange widths, and gage. An added constraint in metallic designs is the minimum ratio of stringer thickness to skin thickness, used to account for adverse stringer-skin interface coupling effects.

The synthesis of metallic multirib structures requires three levels of search. In the first level, stringer spacing is the primary search parameter. The second level involves determination of optimum operating stress levels for the assumed stringer spacing. The third optimization level is designed to determine optimum distributions for available cover material based on assumed stress level and stringer spacing, values assigned by the second- and first-search levels. The search is made on the basis of assuming search parameter values for skin gages and synthesizing stringer geometries for the specified stringer concept from available material. The distribution logic is programmed to maximize area moment of inertia for the skin/stringer section, selecting designs only within the specified constraints for stringer geometries and element minimum gages.

For each search loop total cover, support structure and attachment requirements are determined for the assumed parameter values. The value that produces minimum total structure requirements is selected. Resulting design information is then used for lower-level search operations. This synthesis approach can be controlled to analyze constant spacing or constant number of stringer arrangements. Rib synthesis is based on spring rate requirements for cover column support and for induced rib loads due to cover flexure.

The metallic multispar design option involves synthesis of skin and cap material for specified spar spacing or constant number of spars. The approach considers the effectiveness of intermediate spar caps in resisting bending

loads. Spar webs are sized to similar conditions as rib webs and are assumed to be corrugated. For honeycomb cover construction, strength effect of inserts at the spars and effect of panel thickness on cover stability are considered.

The search logic programmed to synthesize structures for the construction concepts discussed previously involves the determination of minimum required cover/support structure material necessary to resist design loads. Limits on search parameters constrain the search within discrete values so that the configurations for the selected structures reflect practical designs. User inputs can be used to control search parameter values and thus bias the search toward selections of configurations that are more representative of final design concepts. Multiple options programmed allow the user to select one of three types of search procedures:

1. Optimization at each structural station within minimum and maximum values for applicable search parameters:

   - Stringer or spar spacings
   - Number of stringers or spars
   - Ratio of skin gage to total cover $\bar{t}$
   - Rib spacing
   - Stringer heights

   Search values for these parameters are specified in locations 365 through 384 of the input data array.

2. Total torque-box weight optimization search in which the search procedure determines the single value for spacing or number of stringer/spar elements that produces the lightest torque-box design. The selection is dependent on the construction and the analysis mode - spacing or number-of-element search. Specifications for this type of analysis are defined by data in locations 1365 through 1374. This analysis mode, specified by the control word in location 1365, will supersede the optimization mode discussed in item 1.

3. Synthesis of structure to predetermined values of sizing parameters with values specified discretely at each analysis station. Parameter values are input through data sets in locations 721 through 808. These input values supersede the inputs of item 1, and the analysis mode for item 2 should not be used.

In all cases, synthesis results reflect cover/support structure configurations that are sized to strength allowables (P/A stresses), or to allowable stress/material distribution relationships which are based on requirements for (1) general instability as columns or panels or (2) local instability due to crippling or plate buckling.

Front and rear spar webs are synthesized as stiffened plate structures resisting vertical shears. Actual depths of the airfoil at the spars are used for determination of shear loads and material volume. Cap materials are effective bending materials; therefore, they are assumed to vary with cover $\bar{t}$ requirements.

Synthesis procedures for multirib and multispar advanced composite structure designs are similar to the approach used for metallic structures. The following items describe the major differences primarily due to assumptions made for analysis of advanced composite structures:

1. Only longitudinal fibers (0-degree plies) resist axial loads, and cross fibers (±45-degree plies) resist shear loads.

2. All plies contribute to laminate panel stability.

3. Skin material requirements are analyzed for axial loads and panel stability requirements due to combined effects of inplane axial and shear loads.

4. Laminates are synthesized with integer number of lamina. Minimum plate thicknesses are based on requirements for a balanced symmetric system, eight lamina layers consisting of two each of 0-, +45-, -45-, and 90-degree plies. Thickness increases are made by additions of two 0- or 90-degree plies, or two each of ±45-degree plies only, or combinations of all. For honeycomb panels, laminate plies are assumed to be equally divided between the inner and outer face sheets.

5. Addition of ±45-degree plies only are made to increase stiffness levels of panels with inadequate stability stress allowables.

6. Addition of ±45-degree plies only are made to torque-box webs to increase section stiffness to levels required to satisfy torsional stiffness requirements.

7. Different stringer concepts can be specified for the upper and lower covers. However, the spacings or number of elements in each cover will remain the same.

8. Stringer areas consist of 0-degree longitudinal plies only. The synthesis procedures for determining allowable stresses and cover material distributions are programmed to include evaluation of load distribution between skin and stringer elements, based on strain compatibility relationships.

9. Spar/rib web synthesis includes analysis for honeycomb panel designs, as well as corrugated web designs.

10. The covers are assumed to be mechanically attached to ribs and spars. Cover lamina are assumed to be rearranged locally along attachment lines to include filler material, replacing relocated 0-degree lamina, for attachment hole drilling.

11. Lightning protection material (aluminum flame spray) is assumed for all exterior surfaces. Provisions are made for application of sealer films to all interior surfaces.

In the full-depth honeycomb sandwich construction option for advanced composite structures, three optional synthesis procedures are available:

1. Sizing skin requirements so that the sandwich structure will be stable for specified core type and densities.

2. Sizing skin laminates to strength requirements and determining required core densities to satisfy stability requirements.

3. Sizing for optimum skin/core combinations to satisfy strength and stability requirements.

Front and rear spars for these designs are analyzed with the same procedures used for multirib and multispar designs. Evaluation for torsional stiffness is also the same.

Evaluations for structural provisions for major rib bulkheads and chordwise splices are made when user input data direct analysis routines to estimate requirements at each station. Incremental structure weights are predicted by the program, based on data set information in locations 650 through 671 and 1475 through 1497 of the input data array. Root rib and wing-to-fuselage shear tie provisions at the first structural station are evaluated based on load, geometry, and material parameters.

Synthesis of variable-sweep wings consists of the evaluation of idealized torque-box structure, as previously discussed, and synthesis of pivot structure. Pivot estimates replace the idealized structure in the appropriate

structural location. The pivot system analysis is restricted to vertical pin types utilizing straight Teflon-lined bearings. The program is designed so that the pivot estimate is optimum for the specified set of design data. Spanwise and chordwise locations of the pivot centerline are required input data, locations 200 and 201 of the input data array.

The synthesized structural data are used in determining weight and weight distributions. The estimates are based on volumetric integration of the optimized structural elements to which weight indexing factors are applied. Weight increments for unique and for local structural discontinuities, cutouts, doors, etc, are determined through control indicators and weight factors.

Selection of proper material alloy must be made and specified to the module by the user, with consideration made to the temperature and fatigue environment to which the material will be exposed. Consideration must also be made as to the effects of exposure time at temperature on material allowables. Design concepts will dictate whether the selected material should reflect properties of type of alloy and form - sheet, plate, or extrusion. The selected material is specified in the input data set by a material code number; i.e., in location 258 for the torque-box, and location 196 for the pivot lugs. Materials are selected from sequentially stored material property data sets in the material library of the SWEEP data bank. The selected material is identified by code number corresponding to the data set in the library. The contents of this library are presented in Section XI of this volume.

Practical minimum gages for the selected material should be specified by the user. The values used should be compatible with fabrication requirements for the material and structure concepts being evaluated.

Design temperatures are defined for each material selected in locations 159 and 197, respectively. Zero values in these locations will result in placement of SWEEP computed temperature values for analysis. Temperature properties are determined by straight-line interpolation of properties versus temperature data included in the library data set.

Material properties for the advanced composite option are input through the input data sets, locations 1155 through 1163 and 1170 through 1204 for lamina properties, and locations 1164 through 1169 and 580 through 596 for honeycomb core foil properties. The program default material properties are boron/epoxy and 2024-T4 bare aluminum sheet. Material changes must be made with data in the input data set of the component.

ANALYSIS OPTIONS

The execution of the wing and empennage module requires case control card 2 information that is compatible with analysis requirements and variable-data input for each surface. Case control card 2 data in columns 1 through 44, 71, 72, 75, 76, 78, 79, and 80 affect processing of module input data blocks and module execution. Execution of module analysis options are affected by control data in the input data deck for each surface. Setup requirements for four of the major options are explained in the following paragraphs.

Surface Types

Each wing and empennage surface must be described with separate input data blocks. Execution of the module will occur when case control card 2 contains a (0) punch in column 72 for wing, column 75 for horizontal tail, and column 76 for vertical tail. During data processing of case data blocks, a module input data array is set up for each component to be analyzed. The array is initialized from either the SWEEP data bank permanent data sets or the module input data block from the previous case, based on status of column 80 of case control card 2. Component variable data are then read and processed into the array and stored on mass storage records. In any problem case, component variable data are processed only if a data deck with the appropriate deck title appears in the case input data set. Thus, for second and subsequent cases, components may be analyzed without the existence of an input data block.

Internal module logic requires that location 289 of each component input data array contain a code word which identifies the surface type:

0 = Wing surface
-1 = Horizontal tail surface
+N = Vertical tail surface, where N = the number of vertical tail panels

General Data Processing Option

Vehicle and design criteria data input through the GENERAL data deck are processed into design data for the wing and empennage module by the data management and design data development modules of SWEEP. Some of the variable input and calculated data are identical to the information which is also input through component input data decks. These design data are

set up as a separate wing and empennage module input data array. The array data are processed as required during module execution into the component input data array only if the respective variable-data array location is set to zero. For some variables, the transfer is governed initially by a zero value in a control location assigned to the set. Data and control locations affected by module input data processing logic are as follows:

- Vehicle gross weight, load factor, fuel, and useful load data locations 81, 85, 86, 87, 88, 89, 91, 93, 94, 96, 98, 100, and 1280. Control word in location 88.
- Surface-type code in location 289 only for vertical tails. Set to zero for wing.
- Planform geometry parameters in locations 240 through 249 are processed only if location 240 is zero. The value in location 138, planform sweep reference chord element line, is replaced if location 242 is zero.
- Surface positioning data in locations 175, 177, and 178 are set to zero, and the value in 176 is set to calculated value.
- Load reference line location in location 239.
- Torque-box analysis control stations, location 865 through 875, are replaced if location 865 is zero. The code value in location 864 is then set to 2.0.
- Inertia deadweight control word in location 110 is always set to zero for vertical tails and to 1.0 for wing, and is not examined for horizontal tail.
- Torque-box design temperature in location 259.
- Pivot design material, location 196, and design temperature, location 197, are examined only for wings and if location 200, pivot spanwise locator, is not zero. Locations 196 and 197 are set to values in 258 and 259 if zero values are input.
- Pivot design data, locations 200, 201, 202, 203, 197, and 199, are examined and transferred for wing designs only after initial tests for material and temperature.

- Conventional fixed surface flutter Q and material G, locations 253 and 254, and flutter design temperature for advanced composite analysis, location 282.

- Variable-sweep wing flutter data for aft wing position, locations 320, 321, 322, and 323, are controlled by the value in location 320.

- T-tail vertical tail flutter data, locations 310, 335, 337, 338, 339, 358, 359, and 360, based on control word in location 357, T-Tail analysis for vertical tail flutter. Locations 310, 357, 358, and 359 are set to zero for wing and horizontal tail.

- T-tail code word for horizontal tail inertia calculations for vertical tail flutter analysis in location 204. This item is processed during horizontal tail execution only and is set to zero for vertical tail and wing.

- Fuel cell data, locations 206 through 219. All cell data are processed only if the input fuel density for each cell is zero, locations 208 and 215.

- Miscellaneous surface content weight to be distributed uniformly on the torque-box planform for inertia calculations, location 1820.

- Surface contents to be approximated with a spanwise line distribution for inertia claculations, locations 1821 through 1827. If the weight location, 1821, and the outboard point of the distribution line, 1823, are zero, then the data set information is changed to reflect calculated weight distribution along the structural analysis reference line between control station 1 and the tip.

- External concentrated mass items to be located on the wing, seven data sets, 12 items each in locations 1855 through 1938. Each of the seven items is assigned to specific mass components, and transfer of data is made only if the spanwise location

parameter (the second data item in each set) is zero. Items 1 through 4 are for external stores, items 5 and 6 are for wing-mounted nacelles and contents, and item 7 is for wing-mounted landing gear structures. Calculated inertia data (pitch, roll, and yaw) are available for transfer only for the nacelles. Therefore, required data must be input for the other mass items for module estimates of inertias. If data for inertia calculations are not input (items 6 through 11 for each data set), the transferred weight (item 1 of the data set) is set to a negative value to indicate that structural provisions only are to be calculated for that set. The longitudinal location for each mass (item 3) is transferred as fuselage station values; thus, the spanwise location parameter value (item 2) is set to a negative value to indicate fuselage station values.

Torque-Box Design Option

For each surface, the metallic or advanced composite structure synthesis routines are executed in accordance to the values (00) and (01), respectively, punched in columns 39 through 44 of case control card 2, 39 and 40 for wing, 41 and 42 for horizontal tail, and 43 and 44 for vertical tail. Torque-box construction is specified with code information in locations 361 and 461 for metallic structures. Advanced composite construction information is specified by code in locations 430 through 438.

Design Data Generation Option for the Flutter Optimization and Flexible Loads Analysis Programs

Design data for the stand-alone Flexible Loads Analysis and Flutter Optimization Programs can be calculated and punched on data cards for use as input data sets for these programs. Calculations for these options are based on code information in location 271. Output of calculated data is governed by the code in location 280. Related data are input through data sets in locations 272 through 279 and 290 through 309.

Each program requires data which are evaluated at predetermined control stations and referenced to one of the two basic lifting surfaces coordinate reference systems. Data describing the mass characteristics for all items contained in the mold line of the exposed wing are processed as distributed masses, 10 equal-width aerodynamic strips for the Flexible Loads Analysis Program and 11 structural system strips for the Flutter Optimization Program.

Mass properties data must also be evaluated separately for each program, since the flutter design point and vehicle design loading may not be the same as for the critical design loads condition. Furthermore, the critical design point and vehicle loading resulting from the flexible loads analysis may also be different from that resulting from the rigid loads analysis. Thus, mass properties of wing fuel and externally mounted expendable items are evaluated individually for each program, based on user specifications defined in locations 272 through 279. Mass properties summation logic in each system is designed to compute for output the total mass distribution for a specified vehicle loading condition. Remaining wing fuel for the output design data is determined from a fuel usage schedule array in the input data set. Separate data sets are provided to define fuel status for flexible loads design loading and flutter design loading. Estimated full-capacity fuel mass properties data for each fuel cell are scaled to the desired fuel level.

Provisions are made to process two sets of externally mounted concentrated mass items so that effects of store/external fuel configurations can be evaluated by the flexible loads and flutter optimization programs. A loading status schedule similar to that for fuel usage is provided.

During the structural synthesis/weight analysis of lifting surfaces, geometry, design loads, and structural design requirements are evaluated at 11 control stations. Torque-box structures are synthesized at these stations. Unit spanwise weights are determined; then, estimated weights are calculated by integration between these stations. Bending stiffness, EI, and torsional stiffness, GJ, are computed from the synthesis data at each station. These synthesized data provide the necessary distribution data for computing the required data for the flutter optimization and flexible loads analysis programs.

DESIGN FEATURES

Data requirements and descriptions for analysis of surface design features and program analysis options are described in the following paragraphs. Data array locations for data sets and control information are defined. Refer to the input data array list definitions for further descriptions of data sets, control words, and data locations discussed.

Surface Geometry

The basis for input geometric descriptions and module calculations of surface geometry data is a system of straight lines approximating planform and cross-section characteristics. Computations are made by subroutines in overlay (8,0). Computed data are processed and saved for use by all other overlays of the module.

Reference lines are computed to describe theoretical trapezoidal planform properties from standard aerodynamic geometry parameters of lifting surfaces; i.e., area, aspect ratio, taper ratio, sweep, and thickness ratio. Descriptive details to supplement these inputs are specified in terms of either actual dimensions in inches or fractional values of trapezoidal parameters. Detail surface characteristics are described through data sets assigned to input specific types of geometry information, as follows:

Nonlinear Planforms

Blended leading edge and cranked trailing edge planforms are described with data sets in locations 1985 through 2007 and 2008 through 2030, respectively. The data set control word is item 12 of each set. The input information is used to describe local delta chords from the trapezoidal leading and trailing edge lines at up to 11 spanwise points. Interpolations of straight lines between adjacent points are used in computations of true aerodynamic chords.

Cross-Sections

Depths at chordwise locations of airfoils at any spanwise station are computed as functions of the maximum airfoil depths at that station. Values for the reference depth are evaluated as functions of the spanwise location and assuming linear depth variations between spanwise control stations; the maximum depths at the control stations are derived as the product of the true aerodynamic chord and the specified thickness ratio at that station. Thus, cross sections of lifting surfaces are described by values defining surface

maximum depths and airfoil type at discrete spanwise locations. One of two data sets can be used for these specifications.

The first data set, locations 243, 245, 141 and 142, is required input used to specify linear variations in airfoil maximum depths between two spanwise stations, generally the centerline and the theoretical tip. Locations 243 and 245 are thickness ratio values to be used at the spanwise station defined in locations 141 and 142, respectively. If the station values of 141 and/or 142 locate control stations at intermediate spanwise locations, additional control data for the centerline and/or tip station are generated. The maximum depths of these stations are based on the thickness ratio specified in locations 243 and 245, respectively (assumes constant thickness ratio between these created control station and the adjacent input control station).

The second data set, locations 2031 through 2052, is used to specify airfoil depth and control stations at up to 11 spanwise thickness ratio distribu-is used to describe planforms with nonlinear spanwise thickness ratio distributions and for closer depth definitions for planforms with blended leading edges and/or cranked trailing edges. Processing of data set information is specified by a nonzero value in item 2 of the data set. During detail evaluation of cross sections, specifications from this data set are used in lieu of data input through the first data set.

Depths at chordwise locations on airfoils are calculated based on code word value in location 143. The code value indicates to the geometry routines the evaluation procedure and data sets to be used: (1) evaluation based on curve fit equations of airfoil depths, or (2) evaluation based on straight-line interpolation of normalized depth versus chordwise location table data.

A value of 1 through 8 will result in data set selection of polynominal constants for airfoil depths from the SWEEP data bank (locations 1 through 99 of the airfoil data array). This option will result in constant airfoil shapes for all spanwise stations, as represented by the code. Code values and corresponding airfoil shapes are as follows:

1 = 6300-series airfoil

2 = 6400-series airfoil

3 = 6500-series airfoil

4 = 6600-series airfoil

5 = Wedge airfoil

maximum depths and airfoil type at discrete spanwise locations. One of two data sets can be used for these specifications.

The first data set, locations 243, 245, 141 and 142, is required input used to specify linear variations in airfoil maximum depths between two spanwise stations, generally the centerline and the theoretical tip. Locations 243 and 245 are thickness ratio values to be used at the spanwise station defined in locations 141 and 142, respectively. If the station values of 141 and/or 142 locate control stations at intermediate spanwise locations, additional control data for the centerline and/or tip station are generated. The maximum depths of these stations are based on the thickness ratio specified in locations 243 and 245, respectively (assumes constant thickness ratio between these created control station and the adjacent input control station).

The second data set, locations 2031 through 2052, is used to specify airfoil depth and control stations at up to 11 spanwise thickness ratio distribu-is used to describe planforms with nonlinear spanwise thickness ratio distributions and for closer depth definitions for planforms with blended leading edges and/or cranked trailing edges. Processing of data set information is specified by a nonzero value in item 2 of the data set. During detail evaluation of cross sections, specifications from this data set are used in lieu of data input through the first data set.

Depths at chordwise locations on airfoils are calculated based on code word value in location 143. The code value indicates to the geometry routines the evaluation procedure and data sets to be used: (1) evaluation based on curve fit equations of airfoil depths, or (2) evaluation based on straight-line interpolation of normalized depth versus chordwise location table data.

A value of 1 through 8 will result in data set selection of polynominal constants for airfoil depths from the SWEEP data bank (locations 1 through 99 of the airfoil data array). This option will result in constant airfoil shapes for all spanwise stations, as represented by the code. Code values and corresponding airfoil shapes are as follows:

1 = 6300-series airfoil

2 = 6400-series airfoil

3 = 6500-series airfoil

4 = 6600-series airfoil

5 = Wedge airfoil

6 = Arc airfoil

7 and 8 are not used

The code value of 9 specified in location 143 identifies the straight-line interpolation option. Data in locations 145 through 152 are required. This subset provides the option of specifying airfoil shapes at up to four spanwise control stations, locations 145 through 148. Airfoil shapes to be used are identified by code in locations 149 through 152. These code values correspond to the numerical airfoil depth tables found in locations 150 through 399 of the SWEEP data bank airfoil data array.

Torque-Box Description

Torque-box planform geometry information is specified in locations 125 through 129, 135, 136, 137, and 139. Locations 125 through 129, 135, 136, and 137 are used to describe front spar, rear spar, and structual analysis reference line locations on the surface planform. Torque-box reference lines not on constant chord element lines can be positioned properly by using the inboard/outboard control station specifications in this data set. Location 139 is used to specify the spanwise location of the outboard closeout rib. This value is used when (1) the geometry routine is directed to compute equally spaced structural analysis control station data, or (2) fractional values are specified for station positioning in data array locations 865 through 875, under control of torque-box geometry control word in location 864.

Detail torque-box geometry can be input by using the data set in locations 864 through 919. Processing of input data is dictated by the code value of location 864. This data set is organized into 11-element subsets for input of structural analysis station locations, torque-box structural widths and average depths, front spar depths, and rear spar depths.

In surfaces where flutter requirements are calculated by the module, location 340 must contain the theoretical trapezoidal surface area value when options for blended leading edge, cranked trailing edge, or variable thickness ratio descriptions are used, or when input torque-box depths describe nonlinear variations between the exposed root chord and the eleventh station. The area value in location 340 directs the geometry evaluation routine to compute station chord and depth data for flutter analysis based on trapezoidal properties, in accordance with derivation assumptions for the estimation equations.

Values for locations 341 through 345 may also be input. Location 340 causes the geometry routine to examine these locations for nonzero parameter values to be used in lieu of data in locations 241 through 246. The data set in 340 through 345 may be used also to specify adjusted planform geometry

parameters for flutter analysis, particularly location 343, used to compute the exposed panel length for flutter requirement estimates.

Surface Configuation

Variable-Sweep Wing Designs

Data for variable-sweep wing pivot analysis are input in locations 195 through 203, with location 200 as the control data for module execution. Columns 3 and 4 of case control card 2 must contain control code value of (01) for SWEEP evaluation of pertinent airloads and flutter design data. Flutter requirement evaluation by the wing and empennage module consists of determining the envelope of stiffness requirements between the flutter design points for forward and aft wing sweep positions. Flutter analysis control word, location 251, must be specified with the proper value by the user. Required data must be available in locations 252, 253, and 254 for the forward position, and locations 320 through 324 for the aft sweep position. The geometry routines of overlay (8,0) compute the necessary geometric parameters for flutter analysis of the wing in the aft sweep position.

T-Tail Empennage Designs

Empennage configuration is indicated to SWEEP through code information in columns 5 and 6 of case control card 2; T-tail code is (01). This code will cause proper evaluation of airload and flutter analysis data for the wing and empennage module evaluation of the vertical tail. Input data for the vertical tail must contain additional information for module analysis of T-tail vertical tail flutter requirements. These are input in locations 310, 335 through 339, and 357 through 360, with location 357 as the analysis control word for T-tail evaluation, and location 251 as the general flutter evaluation control word. Data in locations 252, 253, and 254 must be available, since the flutter analysis is based on envelope requirements for the vertical tail evaluated as a conventional surface and as a T-tail vertical. The T-tail vertical analysis requires estimates for horizontal tail yaw inertia. One of two methods may be used to provide the proper values for analysis. Method one is to specify the value through input data location 360. The second method is to execute the horizontal tail so that the calculated yaw inertia value will be available for the vertical tail analysis. This option will be executed if location 205 of the horizontal tail input data array is specified as 1.0, and location 360 of the vertical tail input data array is set to zero. Subroutine WØDATA, overlay (17.0), computes the necessary information during evaluation of the horizontal tail, storing the values on record 38 of mass storage file 1. During the execution of the vertical tail, subroutine CCNTL, overlay (8,0), processes the record 38 data

into the variable-data array. The information is used during execution of subroutine GJTT by flutter analysis subroutine GJCAL, overlay (16,0).

Leading and Trailing Edge Structures

Computations for weight and mass distribution information are made by overlay (14,0) subroutines. Estimation procedures are programmed in these subroutines to obtain:

1. Weights and centers of gravity of each major leading and trailing edge structural component

2. 1-g inertia loads - shears, bending moments, and torsional moments - due to the weight distributions of the leading and trailing edge structures

3. Weight inertia characteristics of the distributed structures

The 1-g inertia loads are used during execution of overlay (16,0) to compute initial estimates of 1-g inertia loads. Data resulting from items 1 and 3 are used by overlay (17,0) during processing of module output data.

Fixed leading and trailing edge estimates are made from data sets in locations 1205 through 1234 and 1235 through 1279, respectively, organized into separate subsets for wing, horizontal tail, and vertical tail data. The first item for each subset, input unit weight, is the control location to indicate use of the input value or, if the value is zero, to estimate the weights based on data found in the other locations.

Input data sets for leading edge control surface device descriptions are in data array locations 1500 through 1575. Locations 1500 through 1529 are used to specify device type and position of three devices. The control word for existence of a leading edge device is item 1 for each device. Program estimates for the specified device are made based on input geometry and statistical constants if zero is specified in the input unit weight location, item 9. Weight estimation constants for the three different types of leading edge devices that can be analyzed are in locations 1530 through 1575.

Trailing edge control surface device data sets are in data array locations 1580 through 1819, consisting of subsets for device type and location specifications, weight estimation constants, and weight distribution constants. Spoiler types are defined in locations 1580 through 1609, with item 1 as the control word for evaluation, and item 8 as the control word for statistical weight estimation. Locations 1610 through 1729 are organized

into six subsets of 20 items each for specifying the flap-type devices. Subsets 1 through 4 are used for wing analysis; the first three for flaps, and the fourth set to be used to identify ailerons or flaps. Elevators for horizontal tails are defined with the fifth set. The sixth set is used for vertical tail rudder descriptions. Item 2 of each set is used as the control location to identify existence of a device. Item 19 is the input unit weight location which determines if program statistical estimates are to be made. Weight estimation constants for all device types are in locations 1730 through 1794. Locations 1795 through 1819 contain constants for breakdown of flap-type weights into panel and support components and for estimates of chordwise distributions of support weights.

Miscellaneous Structure and Deadweight Mass Items

Computations for weight and mass distributions of miscellaneous structures and dead weight mass items are made by overlay (15,0) subroutines, except for secondary structure weights which are derived during computations of the torque-box weights. The output requirements for overlay (15,0) are the same as those for overlay (14,0); they are used by the same downstream subroutines.

Secondary Structure

Estimated weights for secondary structural provisions, fillets, exterior finish, doors, etc, are assumed to be a fractional amount of the estimated outer panel weight. Location 603 contains the weight factor value used to compute this weight. The spanwise distribution is assumed to be proportional to the torque-box weight distribution.

Tip Structure

Tip panel weights for the surface are estimated if the value in data array location 139 is less than 1.0. The data set in locations 1955 through 1969 is used in the statistical estimation. Subroutine MISCNT, overlay (15,0), computes the necessary information for tip structures from this data set.

Internal Fuel

Internal fuel and fuel system descriptions are defined by data in locations 206 through 219. The necessary computations are made by subroutine FDIS, overlay (15,0). Two fuel cells can be located within the torque-box. Full-capacity fuel cell mass distributions are estimated first and scaled into required design level values for airload and inertia calculations. Data in

locations 89 through 97 and 159 through 166 are used to determine fuel cell content inertia data for net design loads calculations.

Data in locations 272 and 273 are used to specify fuel cell loads for computations of mass distribution data for the Flexible Loads Analysis Program. Location 276 and 277 are used for Flutter Optimization Program data calculations. These items are processed during execution of subroutines WFLDD and WVFDD, overlay (17,0).

External Concentrated Mass Items

Subroutine CDL, overlay (15,0), processes the input data sets used to describe concentrated mass items.

Seven external concentrated masses can be described through data array locations 1855 through 1938. Twelve locations are used for mass item; the first four locations are weight and location data, the other eight are used for mass inertia calculations, if required. The mass weight data are used as the control word for each set. Mass items 1 and 2, locations 1855 through 1878, define the masses to be treated as expendable items. Inertia load effects for computations of net design airloads are controlled by data in locations 98 through 101 and 167 through 174.

Inertia effects for mass data calculations for the Flexible Loads Analysis Program and the Flutter Optimization Program are controlled with data in locations 274 and 275, and 278 and 279, respectively. Subroutine CDL computes the required mass distribution information which is ordered for output for the Flexible Loads Analysis Program. Mass distribution effects of concentrated mass items are determined by subroutine WVFDD, overlay (17,0), from the output of CDL and the control information in 278 and 279.

Miscellaneous Internal Contents

Internal mass items other than structure, fuel, and fuel systems are processed by subroutines MISCNT and MISCIT, overlay (15,0). Input specifications for internal mass items are described in locations 1820 through 1854. Mass data described by this data set is used for inertia loads and mass inertia calculations. Three data subsets are available for describing the mass and distributions. The first, location 1820, defines uniformly distributed weights within the torque-box. The second, locations 1821 through 1836, is for describing items that may be approximated as distributed weights along spanwise lines such as control surface actuation, controls, and power lines. Two sets of distribution lines are provided for; each set requiring weight, distribution line position, and spanwise weight distribution specifications.

The third set, locations 1837 through 1854, is used to specify weight and locations for up to six concentrated masses, such as large control surface actuators and fittings.

Structural Design Data

Deadweight

Structure weight and mass distribution calculations are always made by the module. The surface weight value to be used during the initial calculations can be specified with location 144. Distribution factors for this weight are in 111, 112, and 113. The control word in location 110 is used to specify whether or not deadweight data are to be used during calculation of net design loads.

Subroutine FDIS, overlay (15,0) uses the information in location 144 to compute initial torque-box weight distributions, necessary for estimates of total structure inertia loads. This output is used by overlay (16,0) during computations of initial design loads. Final torque-box weight distributions are determined from the synthesis/weight analysis results - overlay (10,0) for metallic torque-box structures, and overlay (18,0) for advanced composite torque-box structures. Mass distribution characteristics of the torque-box are determined in overlay (17,0).

Torsional Flutter Requirements

Module calculations of flutter stiffness requirements are controlled with data in locations 251 through 254, 312 through 318, 320 through 324, and 335 through 360. The flutter analysis control word is in 251. Design stiffness values for the 11 structural analysis stations can be input using locations 346 through 356. Flutter analysis results can be scaled using data in locations 312 and 313 through 316, or input of scaling factors for each station in locations 346 through 356.

Flutter requirement estimates are made during execution of subroutine GJCAL, overlay (16,0). Output from this routine consists of the design values for required torque-box torsional stiffness, GJ, used by the structure synthesis subroutines in overlays (10,0) and (18,0). Geometry and pertinent design information are computed and processed by subroutine GEØMW, overlay (8,0), for use by GJCAL.

Design Loads

Airloads data for module analysis can be defined by three options:

1. Analysis by the SWEEP airloads module or input through the WHV LOADS data deck

2. Module calculations of required airloads data

3. Input of design load values in the component input data deck

The first option requires no data inputs in the component data deck except for a control word in location 205 to indicate the type of loads data processing to be used. The second option requires appropriate data in locations 205, 255, 256, 257 and, as required, in locations 232 through 239. The data set in locations 220 through 231 is used to define concentrated airloads data at two locations on the planform, if applicable. Load values computed from this data set are additive to the values computed from distributed airloads. In the third option, design values for airloads are input using the data set in locations 260 through 270, 686 through 719, and 1019 through 1040. Input of torque-box average load intensities instead of shears and moments can be made with data in locations 953 through 1007. These data are processed under control of the code value in location 686. Use of this option results in replacement of SWEEP or module calculated loads data with the input values.

All calculated or input load values are assumed to be for the limit load condition. Computed net design loads are factored with the value found in location 122 to derive ultimate design loads. The synthesis and stress analysis procedures are based on ultimate loads and stress allowables.

Design airloads information is processed initially by subroutine ALØAD, overlay (16,0). For metallic torque-box analyses, subroutine PRØG, overlay (9,0), controls the computations for torque-box design loads. Design loads for advanced composite analysis is processed by subroutine ACLØAD, overlay (18,0). Subroutine ACPRØG of this overlay controls the computations for torque-box design loads.

The constants in locations 931 through 952 are cover compression and tension load calibration factors. Computed cover load intensity values are multiplied by these factors to account for the crowning effects of the true torque-box section relative to the assumed average rectangular torque-box section. Factors for shear load on the front spar and rear spar are in locations 842 through 863. These data items are used by the structural synthesis subroutines in overlays (10,0) and (18,0).

Torque-Box Design Synthesis

Data sets used for definitions of torque-box design are in locations 361 through 470, 521 through 528, 597, 598, 599, 650 through 671, and 721 through 830. Some of the more important data items in these locations are discussed in the following paragraphs. Overlay (9,0), (10,0), and (18,0) subroutines use these inputs during the synthesis/weight analysis calculations.

Construction Concepts

The torque-box construction concept for metallic design is specified by code word in locations 361 and 461. Location 361 specifies the stringer type to be used for multirib designs, while location 461 specifies multispar/plate or multispar/honeycomb panel designs. Multirib analysis requires that location 461 be zero and, for multispar designs, locations 361 should be set to 2.0. The values in locations 365, 366, and 375 through 384 must be compatible with the construction concepts. These items are organized for multirib designs. In the multispar analysis, data assigned for ribs and stringers pertain to intermediate spars; the webs are defined by rib data, and the caps are defined by stringer data. The value in location 382 is the number of stringer or intermediate spar elements, with internal arrangement specified by the code value in location 383.

The control code in location 367 indicates if the analysis will be made using data input in locations 721 through 808. Multispar/honeycomb panel data are defined in locations 462 through 468.

Advanced composite construction concepts are specified in locations 430 through 438. Data in locations 375 through 384 and 399 are used for multirib analysis, and data in locations 380 through 383 and 399 are used for multispar plate and honeycomb panel designs. The honeycomb panel data in locations 462 and 464 through 468 also are used for the multispar honeycomb panel analysis. Analysis of advanced composite full-depth honeycomb sandwich structures requires bond density value in location 464. The control value in locations 361 and 461 should be compatible with the construction concept code specified in locations 430 and 431 for advanced composite analysis.

Support structure concepts for metallic designs are limited to corrugated sine wave webs for ribs and intermediate spars, and stiffened plate webs for the front and rear spars. Data for these components are specified in locations 400 through 406 for ribs and intermediate spars, and 410 through 426 for the front and rear spars. Corrugated web or honeycomb panel concepts can be specified for advanced composite structures, using construction code values in locations 435, 436, and 437. Honeycomb panel core thickness for these structures are defined in locations 457, 458, and 459, respectively. Data in

locations 427 and 428 are needed for the front and rear spar advanced composite analysis. Advanced composite intermediate spar cap areas are derived from cover skin thicknesses based on the factor in location 429.

Torque-Box Analysis Constants

Minimum gage values for metallic analysis are in locations 370 through 374 and 394. The constants in locations 61, 1472, 1479, and 1480 are used as minimum thickness values for splice and bulkhead calculations. Minimum gages for advanced composite structures are based on minimum laminate layup consisting of eight layers of lamina. Lamina thickness is specified in data location 1162 as part of the material properties data set for advanced composite analysis. Locations 440 through 443 are the minimum number of 0-degree plies to be used for upper and lower cover stringer designs.

Stability equation constants for metallic analysis are as follows:

- Locations 362, 363, 364 - Plate buckling coefficients for cover design
- Locations 408 and 409 - Sheet crippling coefficients for cover design
- Location 407 - End fixity coefficient for skin-stringer columns
- Locations 401 and 402 - Local and general-stability coefficients for rib and intermediate spar webs, sine wage corrugation
- Locations 550 through 573 - Table of plate aspect ratio versus stability coefficients for evaluation of shear stress allowables for front and rear spar webs

Stability coefficients for all advanced composite plates and webs, except stringer elements, are analysis routine constants or derived values. Stringer element coefficients are in locations 598 and 599.

Ultimate Allowable Stresses

Ultimate allowable stress cutoff values for metallic designs can be specified in terms of actual stress values or fractions of the material ultimate stresses. Data locations for input of these values are 385 through 388, 398, 412, and 413. Cutoff stresses for advanced composite analysis can only be specified by adjustments of ultimate stresses specified for 0-degree lamina in locations 1159, 1160, and 1161.

Weight Calibration Factors

The final estimated weights for lifting surfaces are computed by the application of weight factors to derived weights for each of the major structural components of the surface. Specified coefficients are first applied to the structural elements assigned to these components. The total sum of all the major components is then adjusted by a single total surface coefficient, specified in data array location 250.

The major structural components and the weight coefficient data locations are listed in the following paragraphs. Data sets containing element weight coefficients are also identified.

Torque-Box Structure

The coefficient value in location 600 is applied to the outer panel torque-box weight. This coefficient is not applied to the incremental weights necessary to satisfy flutter stiffness requirements. Torque-box element coefficients are in locations 604 through 627. Shear-tie weight factor is in 520. Locations 1288 through 1294 contain weight factors for the structural attach weights computed for the seven external concentrated masses. The data set in locations 650 through 660 is used to indicate locations of major bulkheads and as weight factors. Locations 1088 through 1107 contain individual panel weight factors and input incremental weights for calibration of torque-box weight and panel distributions.

Pivot Structure

The data set in locations 530 through 536 contain weight coefficients for the pivot structures. Location 530 is the total pivot factor.

Center-Section Structure

Locations 481 through 505 contain the center-section weight coefficient data set. The total center-section factor is location 481. The other factors are organized and used in the same manner as the outer-panel torque-box data.

Leading Edge Structure

The total leading edge structure weight coefficient is in location 601. Individual fixed leading edge factors for wing, horizontal tail, and vertical tail are in 1206, 1216, and 1226, respectively. Weight factors for the three control surface devices that may be specified are in 1509, 1519, and 1529.

Trailing Edge Structure

The total trailing edge structure weight coefficient is in location 602. Individual fixed trailing edge factors for each surface type are in 1236, 1251, and 1266. Spoiler coefficients are in 1588 and 1603; wing flap-type control surface coefficients are in 1629, 1649, 1669, and 1689; elevator coefficient is in 1709; and rudder coefficient is in 1729.

Tip Structure

Location 1956 contains the weight coefficient for surface tip structure.

Secondary Structure

Location 603 contains the weight coefficient for secondary structures. Secondary structure weights are estimated with this factor applied to the total weights computed for the surface, before application of the specified total surface factor in location 250.

MODULE STRUCTURE

The overlay subroutine structure for each overlay of the wing and empennage module is shown in Figures 2 through 9. These overlays are presented in the general order of execution. The order of subroutine execution by the primary control routine is left to right. Table 2 contains names and short descriptions of the subroutines required in each overlay.

MODULE EXECUTION

SWEEP is restricted to operate as a two-level overlay program, thus, the wing and empennage module overlays are executed as chain programs. SWEEP control program ØLAY00 contains the necessary logic for execution of all module overlays. Horizontal tail surfaces are analyzed first, followed by analysis of vertical tails, and last, the wing. The internal control codes used by ØLAY00 to determine if each surface is to be analyzed is stored in locations 2, 5, and 6 of array IFL, labeled common block IFLØW. (Table 8, Volume II, "Program Integration and Data Management Module"). The contents of these cells are as specified in columns 72, 75, and 76 of case control card 2 (Table 4, Volume II). ØLAY00 stores the proper code value used to identify the surface type being analyzed in location 2 of array XMISC.

Program ØLAY00 also selects the torque-box structural synthesis/weight analysis overlays to be executed for the surface - overlay (9,0) and (10,0) for metallic designs, and overlay (18,0) for advanced composite designs. Execution is dictated by the contents of IFL array locations 11 through 13, as specified by input control codes on case control card 2, columns 39 through 44.

Program ØLAY00 prints module execution heading data for each surface analyzed if directed by print control code in column 40 case control card 1 (Table 3, Volume II). The printed heading identifies the surface, the general torque-box material type, and the module overlays to be executed.

EXECUTION OF METALLIC TORQUE-BOX DESIGN OVERLAYS

The metallic torque-box analysis overlays (9,0) and (10,0) are executed in tandem. Overlay (10.0) is executed under control of subroutine TBØPT in overlay (9,0). The function of overlay (10,0) is to synthesize torque-box structure and evaluate the structural weight requirements to given sets of criteria specified by subroutine TBØPT. The analysis loops for gross weight passes and deadweight iterations are controlled in the logic the between subroutines PRØG and TBØPT of overlay (9,0). Overlay (10,0) is executed based on these controls plus the optional optimization loop control by TBØPT.

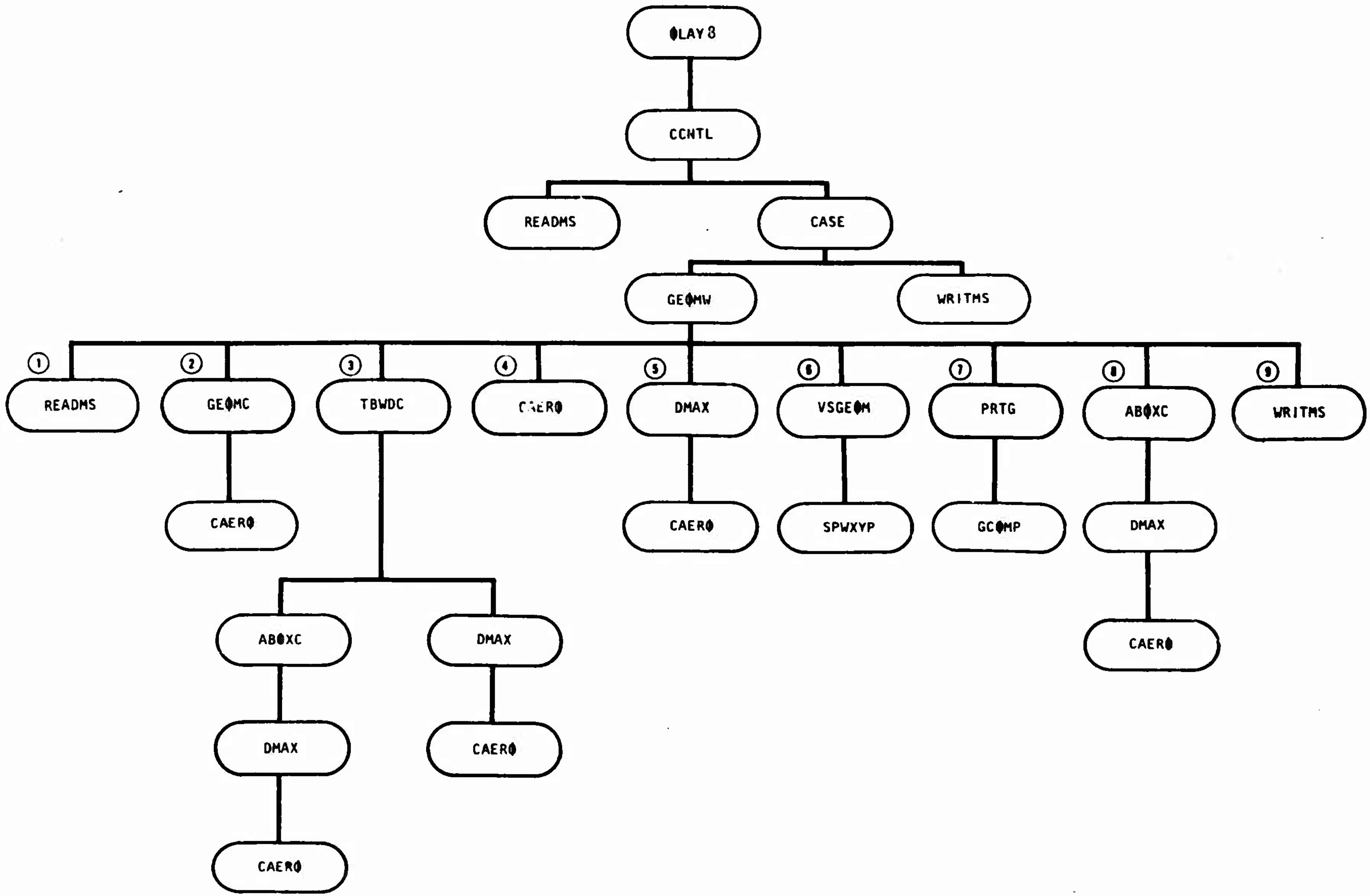


Figure 2. Overlay (8,0) - input data processing and geometry analysis.

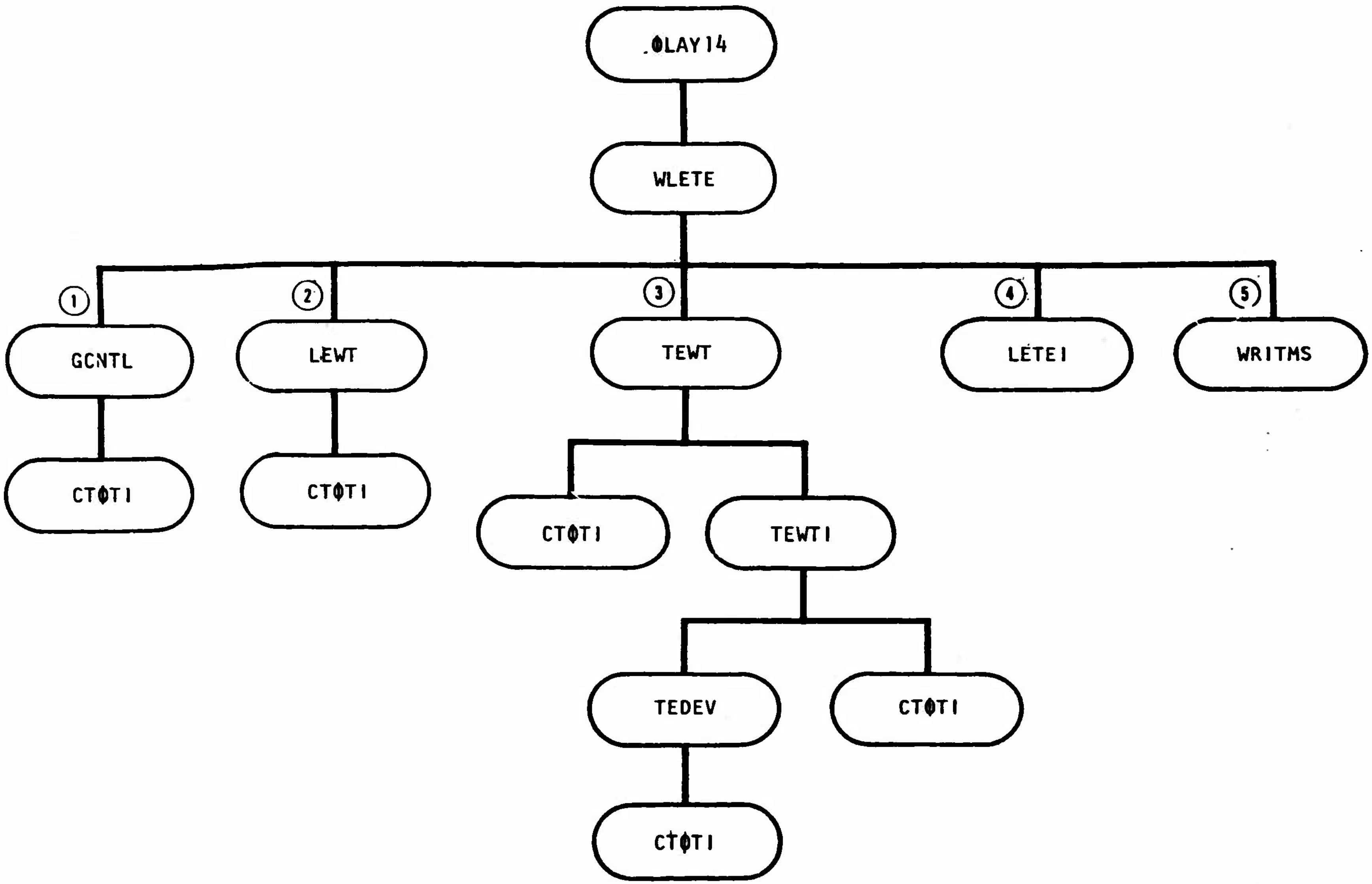


Figure 3. Overlay (14,0) - leading and trailing edge structures, weight and mass properties analysis.

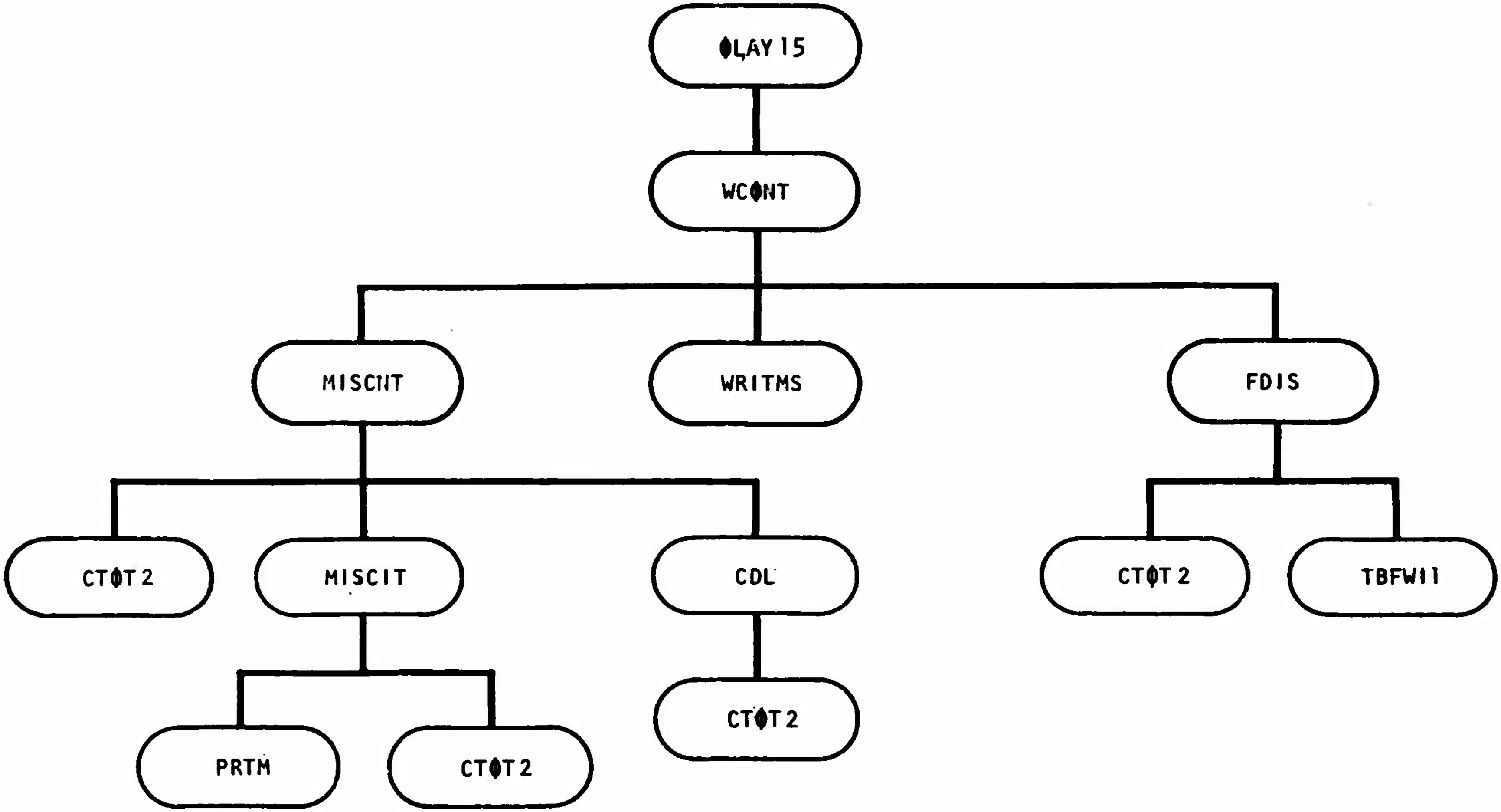


Figure 4. Overlay (15,0) - fuel, contents and concentrated masses, weight and mass properties analysis.

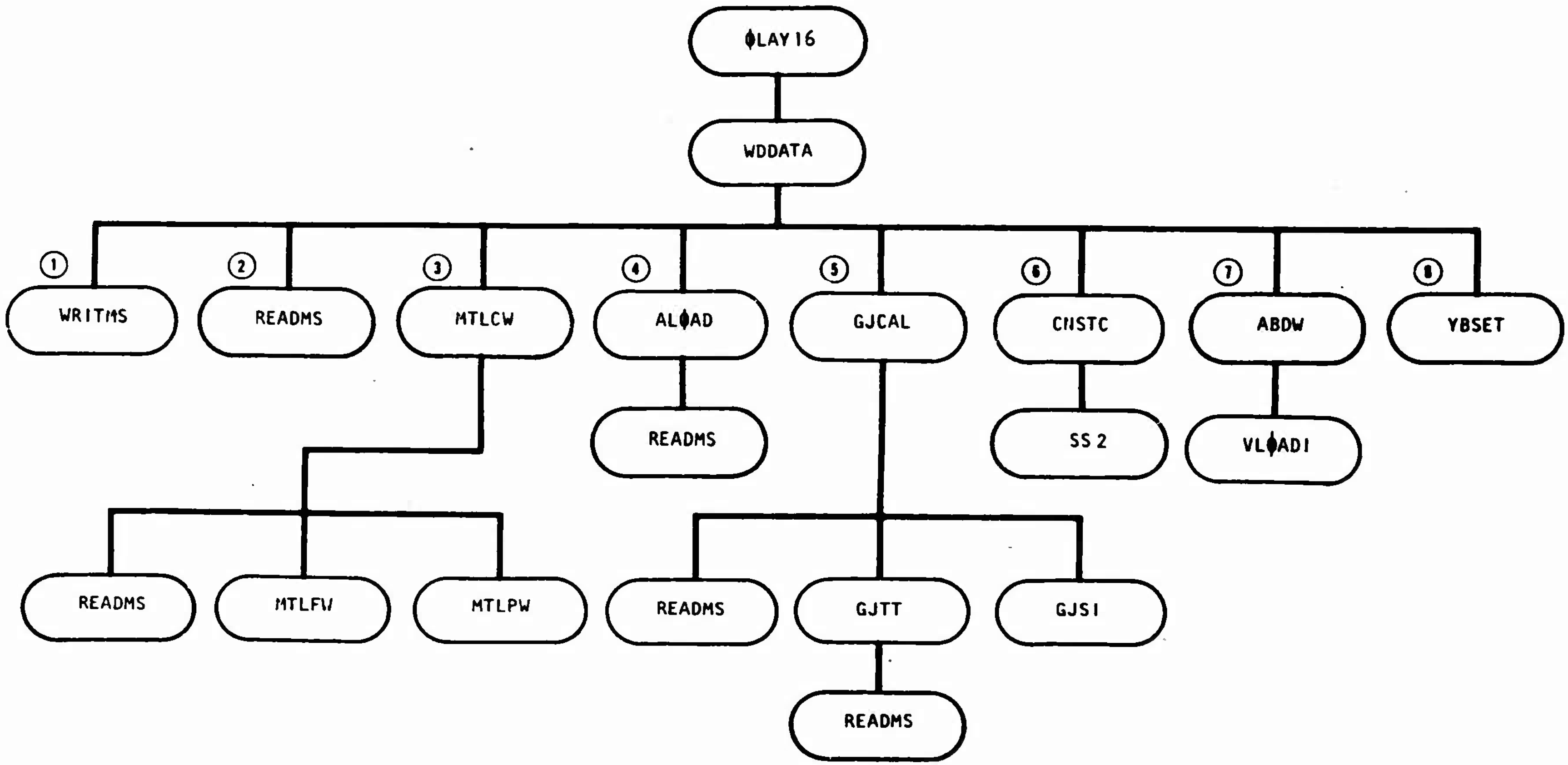


Figure 5. Overlay (16,0) - design data for torque box analysis.

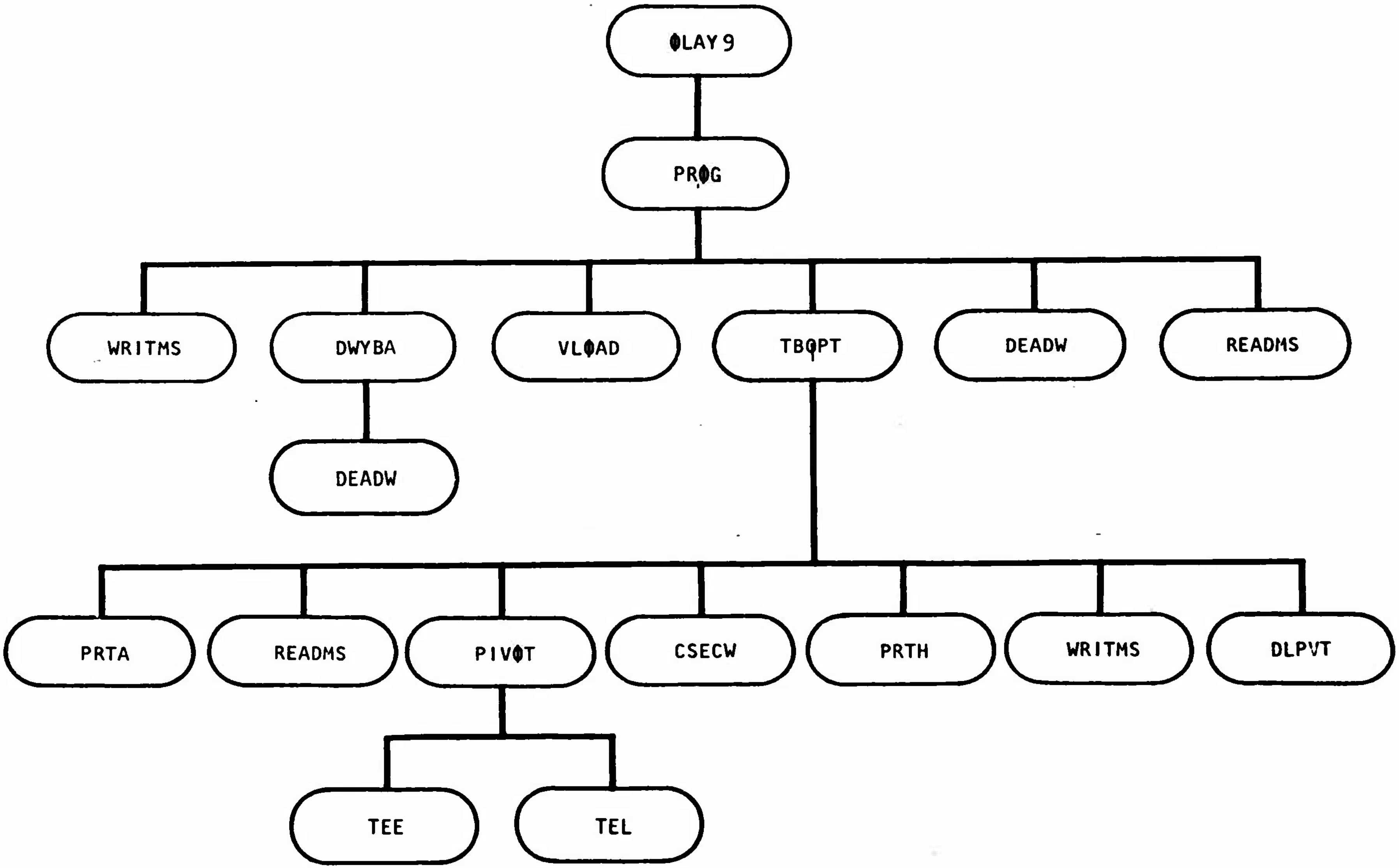


Figure 6. Overlay (9,0) - torque-box structural synthesis/weight analysis for metallic designs - No. 1.

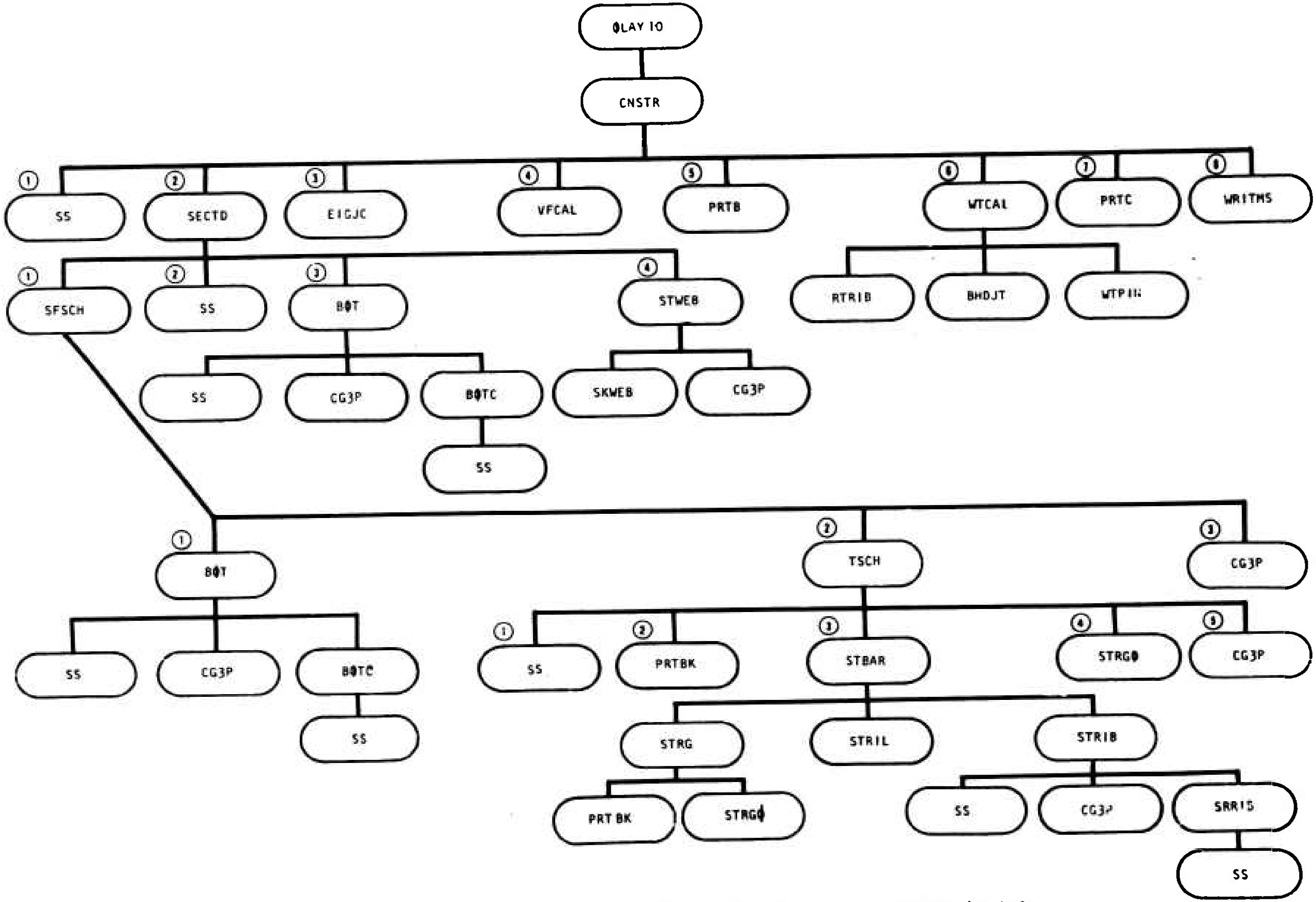
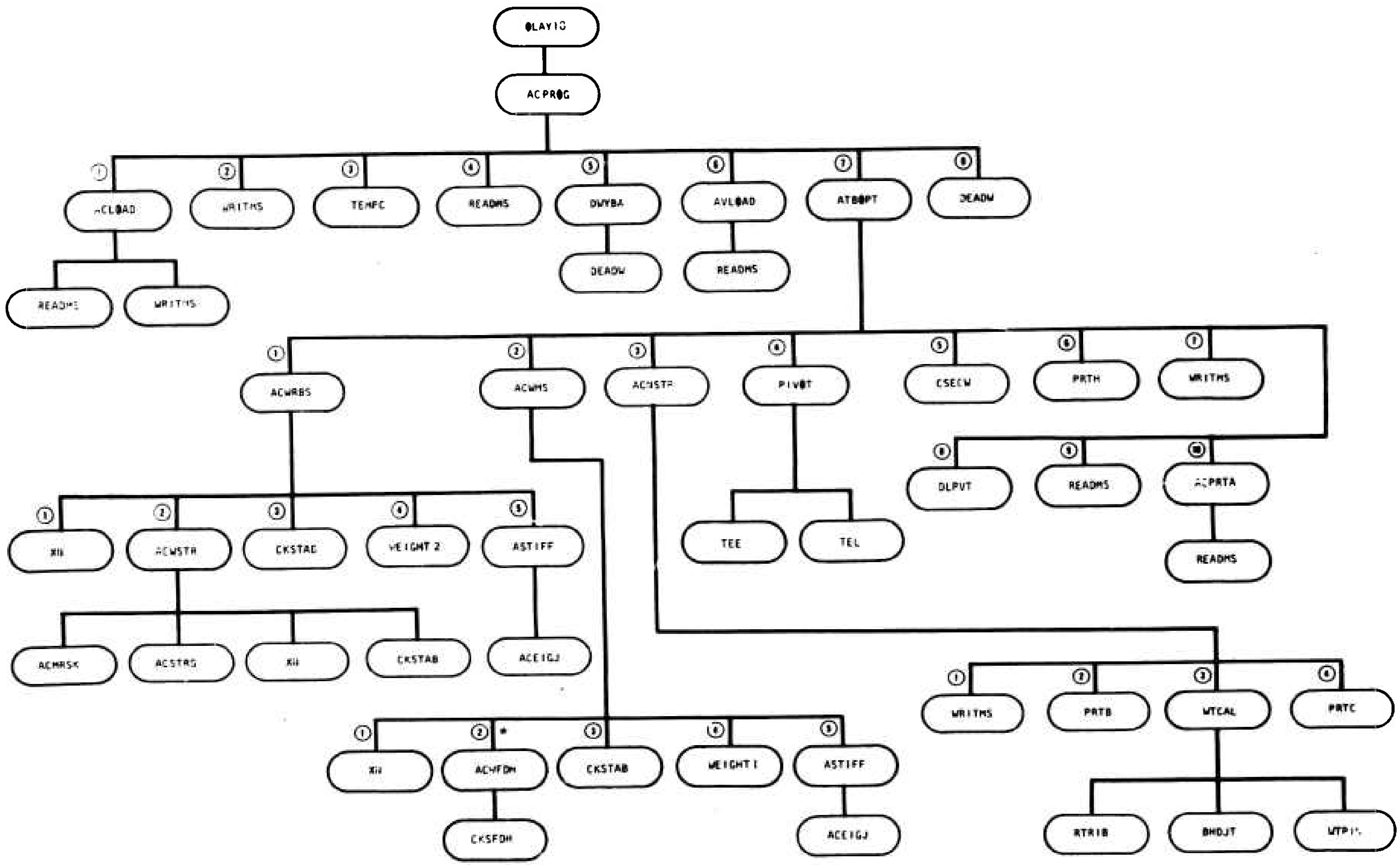


Figure 7. Overlay (10,0) - torque-box structural synthesis/weight analysis for metallic designs - No. 2.



*This step is used only for FDM options.

Figure 8. Overlay (18,0) - torque-box structural synthesis/weight analysis for advanced composite designs.

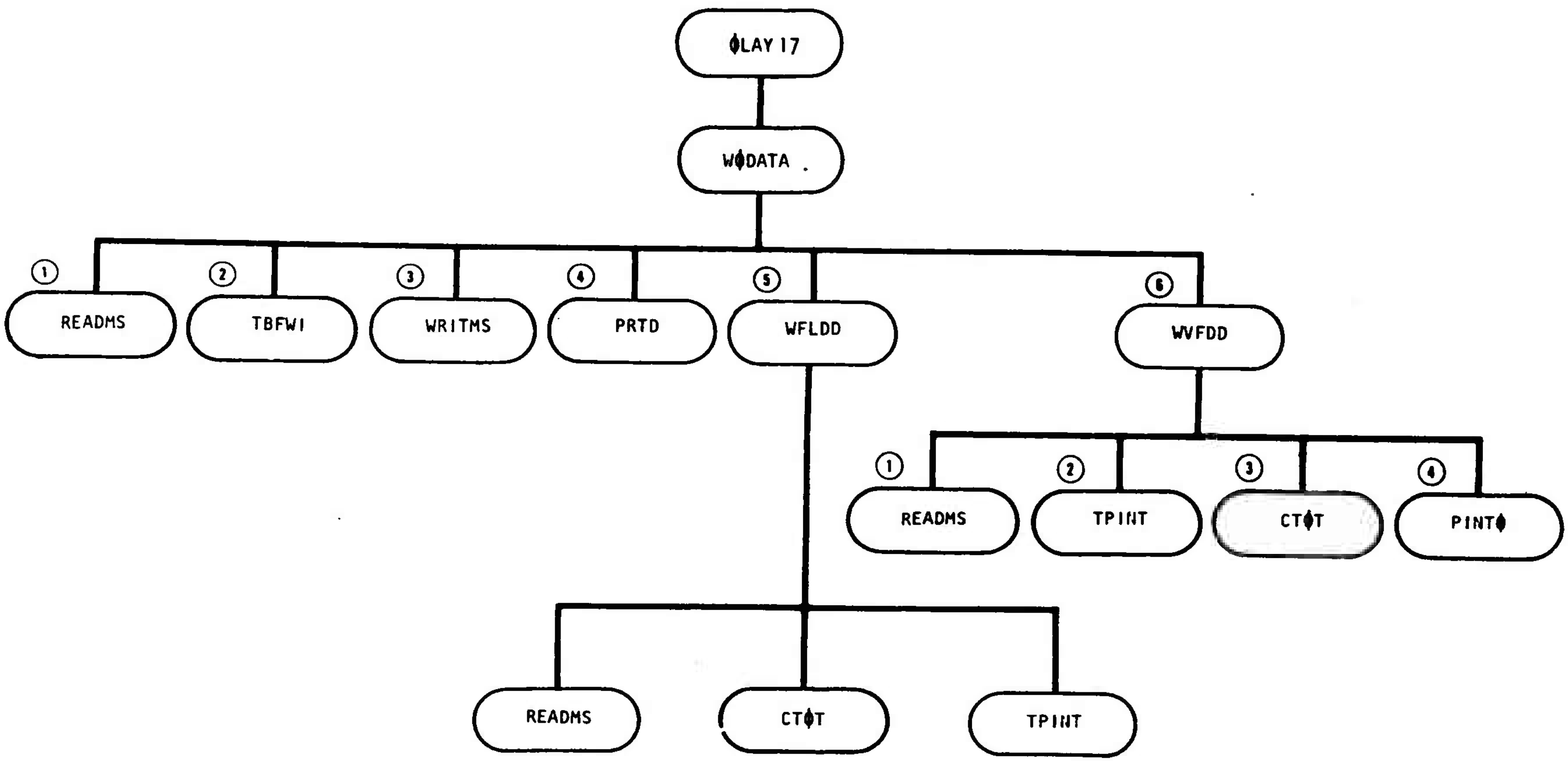


Figure 9. Overlay (17,0) - data generation and output data processing.

TABLE 2. WING AND EMPENNAGE MODULE OVERLAY SUBPROGRAM LIST

DECK NAME	OLAY	- . - . - DESCRIPTION - . - . - . - . - . - . - . -
*****OVERLAY(8,0)--INPUT DATA PROCESSING & GEOMETRY ANALYSIS*****		
OLAY8	08	PROGRAM FOR FIRST OVERLAY OF WING-EMPENNAGE MODULE
ABOXC	08	TORQUE-BOX CROSS-SECTIONAL AREA INTEGRATION
CAERO	08	TRAPEZOIDAL/TOTAL PLANFORM CHORD EVALUATION
CASE	08	GENERAL DATA INITIALIZATION AND CONTROL
CONTL	08	INITALIZATION - DATA TRANSFER FROM GENERAL DATA
DMAX	08	AIRFOIL DEPTH EVALUATION
GEOMP	08	WING,H,V GEOMETRY DATA PROCESSING FOR OUTPUT
GEOMC	08	GENERAL PLANFORM GEOMETRY AND T/C DATA SETUP
GEOMW	08	WING,H,V GEOMETRY EVALUATION AND CONTROL
PRTG	08	WING,H,V GEOMETRY DATA PRINT
SWPXYP	08	EVALUATION OF X,Y COORD. OF ROTATED POINT
TBWDC	08	TORQUE-BOX SECTION GEOMETRY EVALUATION
VSGEOM	08	ROTATED SURFACE PLANFORM GEOMETRY EVALUATION
*****OVERLAY(14,0)--LE & TE STRUCTURES, WT & MASS PROP ANALYSIS*****		
OLAY14	14	PROGRAM FOR SECOND OVERLAY OF WING-EMPENNAGE MODULE
CTOTI	14	PLANFORM CHORD EVALUATION
GCNTL	14	TORQUE-BOX, LE, TE GEOMETRY DATA SETUP FOR WT ANALYSIS
LETEI	14	LE/TE WEIGHT INTEGRATION
LEWT	14	LE WEIGHT AND DISTRIBUTION EVALUATION
TEDEV	14	TRAILING EDGE DEVICE WEIGHT ESTIMATION
TEWT	14	TE WEIGHT/DISTRIBUTION EVALUATION AND CONTROL
TEWTI	14	TE DEVICE WEIGHT/DISTRIBUTION EVALUATION
WLETE	14	LEADING EDGE - TRAILING EDGE WEIGHT ESTIMATION CONTROL

TABLE 2. WING AND EMPENNAGE MODULE OVERLAY SUBPROGRAM LIST (CONT)

DECK NAME	OLAY	- . - . - DESCRIPTION - . - . - . - . - . - . - . -
*****OVERLAY(15,0)--FUEL/CONTENTS/CONC MASSES, WT & MASS PROP ANALYSIS		
OLAY15	15	PROGRAM FOR THIRD OVERLAY OF WING-EMPENNAGE MODULE
CDL	15	EXTERNAL CONCENTRATED DEADWEIGHT EVALUATION
CTOT2	15	PLANFORM CHORD EVALUATION
FDIS	15	FUEL WEIGHT/DIST AND INITIAL T-BOX WT. EVALUATION
MISCIT	15	MISC CONTENT WEIGHT INTEGRATION
MISCNT	15	MISC CONTENT WEIGHT/DISTRIBUTION EVAL/CONTROL
PRIM	15	DESIGN DATA PRINT - MISC. CONTENT MASS DATA
TBFWIT	15	FUEL/TORQUE-BOX WEIGHT INTEGRATION
WCONT	15	CONTROL FOR WEIGHT ESTIMATION OF CONTENTS
*****OVERLAY(16,0)--DESIGN DATA FOR TORQUE-BOX ANALYSIS*****		
OLAY16	16	PROGRAM FOR FOURTH OVERLAY OF WING-EMPENNAGE MODULE
ABDW	16	INITIAL STRUCTURE AND CONTENT INERTIA LOAD SETUP
ALOAD	16	DESIGN AIRLOAD PROCESSING
CNSTC	16	STRUCTURAL SYNTHESIS CONSTANTS AND DATA SETUP
GJCAL	16	FLUTTER GJ REQD CONTROL AND EVALUATION
GJSI	16	FLUTTER GJ REQD CALCULATION AT STATION I
GJTT	16	FLUTTER GJ REQUIRED FOR T TAILS
MTLCW	16	MATERIAL PROPERTY PROCESSING CONTROL
MTLFW	16	MATERIAL PROPERTY CURVE FIT
MTLPW	16	MATERIAL PROPERTY DATA PRINT
SS2	16	STRESS-STRAIN CURVE EVALUATION AT GIVEN STRESS
VLOADI	16	ULTIMATE NET DESIGN LOADS PROCESSING
WDDATA	16	DESIGN DATA GENERATION CONTROL
YBSET	16	EFFECTIVE BOX DEPTH INITIALIZATION

TABLE 2. WING AND EMPENNAGE MODULE OVERLAY SUBPROGRAM LIST (CONT)

DECK NAME	OLAY	- . - . - DESCRIPTION - . - . - . - . - . - . - . -
*****OVERLAY(9,0)--T-BOX STRUCT SYN/WT ANALYSIS--METALLIC DESIGNS #1**		
OLAY9	09	PROGRAM FOR FIFTH OVERLAY OF WING-EMPENNAGE MODULE
CSECW	09	CENTER-SECTION WEIGHT EVALUATION
DEADW	09	CURRENT TORQUE-BOX INERTIA LOAD EVALUATION
DLPVT	09	EVALUATION OF BOX STRUCTURE REPLACED BY PIVOT
DWYBA	09	DEADWEIGHT/COUPLE ARM ADJUSTMENT FOR PASS I&1
PIVOT	09	WING PIVOT SYNTHESIS AND WEIGHT EVALUATION
PROB	09	TOTAL SURFACE WEIGHT SYNTHESIS CONTROL
PRTA	09	DESIGN DATA PRINT-TYPE A TORQUE-BOX SYNTHESIS SUMMARY
PRTF	09	DESIGN DATA PRINT-TYPE H C-SEC/PIVOT DESIGN SUMMARY
TBOPT	09	TOTAL TORQUE-BOX WEIGHT OPTIMIZATION CONTROL
TEE	09	PIVOT DESIGN/SYNTHESIS DATA EVALUATION
TEL	09	PIVOT DESIGN/SYNTHESIS DATA EVALUATION
VLOAD	09	ULTIMATE NET DESIGN LOADS PROCESSING
*****OVERLAY(10,0)--T-BOX STRUCT SYN/WT ANALYSIS--METALLIC DESIGNS #2*		
OLAY10	10	PROGRAM FOR SIXTH OVERLAY OF WING-EMPENNAGE MODULE
BHDJT	10	BULKHEAD AND JOINT WEIGHT EVALUATION
BJT	10	INTERPOLATION/EVALUATION FOR FC OR B/T
BUTC	10	PLATE BUCKLING B/T EVALUATION
CG3P	10	PARABOLIC CURVE FIT AND EVALUATION
CNSTR	10	TORQUE-BOX SYNTHESIS/WEIGHT ANALYSIS CONTROL
EIGJC	10	SECTION EI AND GJ STIFFNESS EVALUATION
PRTB	10	DESIGN DATA PRINT-TYPE B SECTION DESIGN DETAIL SUMMARY
PRTBK	10	DESIGN DATA PRINT-DETAIL SYNTHESIS SEARCH DATA
PRTC	10	DESIGN DATA PRINT-TYPE C SECTION DESIGN DETAIL SUMMARY
RTRIB	10	ROOT RIB AND SHEAR TIE WEIGHT EVALUATION
SECTD	10	TORQUE-BOX SECTION SYNTHESIS-SEARCH LEVEL 1 CONTROL
SFSCH	10	SEARCH LEVEL 2 CONTROL--DESIGN STRESS

TABLE 2. WING AND EMPENNAGE MODULE OVERLAY SUBPROGRAM LIST (CONT)

DECK NAME	OLAY	- . - . - DESCRIPTION - . - . - . - . - . - . - . -
SKWEB	10	SPAR WEB CRITICAL STRESS EVALUATION
SRRIB	10	RIB T-WEB EVALUATION
SS	10	STRESS-STRAIN CURVE EVALUATION AT GIVEN STRESS
STBAR	10	TOTAL COVER/SUPT STRUCTURE T-BAR EVALUATION
STRG	10	STRINGER/CAP OPT MATL DIST/GEOMTRY EVALUATION
STRGD	10	STRINGER/CAP GEOMETRY/BOUNDARY INITIALIZATION
STRIB	10	RIB T-BAR SYNTHESIS AND CONTROL
STRIL	10	STRINGER COLUMN LENGTH EVALUATION
STWEF	10	FRONT/REAR SPAR CAP/WEB EVALUATION AND CONTROL
TSCH	10	SEARCH LEVEL 3 CONTROL--OPTIMUM T&SKIN</A&STR,CAP<
VFCAL	10	SECTION TORSIONAL STIFFNESS REQMT EVALUATION
WTCAL	10	SECTION/PANEL WEIGHT EVALUATION AND CONTROL
WTPIN	10	SECTION WEIGHT/INCH EVALUATION

*****OVERLAY(18,0)--T-BOX STRUC SYN/WT ANALYSIS--ADV/COMP DESIGNS*****

OLAY18	18	PROGRAM FOR EIGHTH OVERLAY OF WING-EMPENNAGE MODULE
ACEIGJ	18	TORQUE-BOX EI/GJ EVALUATION - ADV. COMP. ANALYSIS
ACLOAD	18	DESIGN LOAD DATA PROCESS - ADV. COMP. ANALYSIS
ACMRSK	18	SKIN-STR LOAD DIST, SKIN STABILITY -ADV.COMP.ANALYSIS
ACNSTR	18	SECTION DESIGN DATA/WT ANALYSIS CONTROL - ADV. COMP.
ACPROC	18	TOTAL SURFACE WEIGHT SYNTHESIS CONTROL - ADV. COMP.
ACPRTA	18	DESIGN DATA PRINT-TYPE A TORQUE-BOX SYNTHESIS SUMMARY
ACSTRG	18	STRINGER GEOMETRY/SECTION PROPERTIES-ADV.COMP.ANALYSIS
ACWFDH	18	FULL DEPTH HC SECTION OPTIMIZATION - ADV.COMP.ANALYSIS
ACWMS	18	M/SPAR, FDH TORQUE-BOX SYNTHESIS - ADV.COMP.ANALYSIS
ACWRBS	18	M/RIB TORQUE-BOX SYNTHESIS - ADV. COMP. ANALYSIS
ACWSTR	18	SKIN-STR/RIB SECTION OPTIMIZATION - ADV.COMP.ANALYSIS
ASTIFF	18	TORQUE-BOXSTIFFNESS EVALUATION - ADV.COMP.ANALYSIS
ATBOPT	18	ADV. COMP. TORQUE-BOX SYNTHESIS CONTROL
AVLOAD	18	NET ULT. LOADS CALC. - ADV. COMP. ANALYSIS
BHDJT	18	BULKHEAD AND JOINT WEIGHT EVALUATION

TABLE 2. WING AND EMPENNAGE MODULE OVERLAY SUBPROGRAM LIST (CONCL)

DECK NAME	'LAY	- . - . - DESCRIPTION - . - . - . - . - . - . - . -
CKSFDH	18	STABILITY CHECK FOR FULL DEPTH HC CORE -ADV.COMP.SKINS
CKSIAL	18	COMP/SHEAR STABILITY CHECK FOR ADV. COMP. PANELS
CSECW	18	CENTER-SECTION WEIGHT EVALUATION
DEADW	18	CURRENT TORQUE-BOX INERTIA LOAD EVALUATION
DLPVT	18	EVALUATION OF BOX STRUCTURE REPLACED BY PIVOT
DWYDA	18	DEADWEIGHT/COUPLE ARM ADJUSTMENT FOR PASS 1&1
PIVOT	18	WING PIVOT SYNTHESIS AND WEIGHT EVALUATION
PRTE	18	DESIGN DATA PRINT-TYPE E SECTION DESIGN DETAIL SUMMARY
PRTC	18	DESIGN DATA PRINT-TYPE C SECTION DESIGN DETAIL SUMMARY
PRTH	18	DESIGN DATA PRINT-TYPE H C-SEC/PIVOT DESIGN SUMMARY
RTRIB	18	ROOT RIB AND SHEAR TIE WEIGHT EVALUATION
TEE	18	PIVOT DESIGN/SYNTHESIS DATA EVALUATION
TEL	18	PIVOT DESIGN/SYNTHESIS DATA EVALUATION
TEMPC	18	MATERIAL PROPERTIES EVAL FOR ADV. COMP. ANALYSIS
WEIGH1	18	SECTION WT/INCH FOR ADV. COMP M/SPAR, FOR TORQUE-BOX
WEIGH2	18	SECTION WT/INCH FOR ADV. COMP. M/RIB TORQUE-BOX
WTCAL	18	SECTION/PANEL WEIGHT EVALUATION AND CONTROL
WTPIN	18	SECTION WEIGHT/INCH EVALUATION
XN	18	EVALUATION OF NO. OF N-PLIES FOR GIVEN L,M PLIES

*****OVERLAY(17,0)--DATA GENERATION & OUTPUT DATA PROCESSING*****

OLAY17	17	PROGRAM FOR SEVENTH OVERLAY OF WING-EMPENNAGE MODULE
CTOT	17	PLANFORM CHORD EVALUATION
PINTD	17	MASS/DESIGN DATA PUNCH/PRINT FOR FLUT. OPT. PROGRAM
PRTD	17	WING,H,V WEIGHT SUMMARY PRINT
TBFWI	17	FUEL/TORQUE-BOX WEIGHT INTEGRATION
TPINT	17	PARABOLIC CURVE FIT AND EVALUATION
WFLDD	17	MASS/DESIGN DATA CALC/OUTPUT FOR FLEX LOADS PROGRAM
WODATA	17	WING,H,V ANALYSIS OUTPUT DATA CONTROL
WVFDD	17	MASS/DESIGN DATA CALC. FOR FLUTTER OPT. PROGRAM

The TBØPT logic requires six calls to subroutine CNSTR, the basic control routine for overlay (10,0), with mandatory returns to the appropriate parts of TBØPT. The chain-type overlay structure and the position of TBØPT relative to the SWEEP control program results in the use of a status code word to control the logic flow from TBØPT to CNSTR. Location 39 of array XMISC is used to store control code values to be used to control the path to be followed during the calls to and returns from CNSTR.

The calls to CNSTR from TBØPT require that control be returned to subroutine PRØG, which returns to program ØLAY9 and then to SWEEP control program ØLAY00 before overlay (10,0) can be loaded and subroutine CNSTR executed. The return from CNSTR follows the same path. The logic path in ØLAY00, PRØG, and TBØPT is dictated by the code value in XMISC(39).

MODULE STORAGE ARRANGEMENT

BLANK COMMON

Data computed by wing and empennage module subprograms are primarily stored in blank common. The blank common block in each overlay is blocked into six primary regions, each assigned array names as shown in Table 3. Access to all data cell locations in blank common is made through direct references to these arrays or through subarray and variable names equivalenced to these arrays.

The D array is used to store case input data. Array ND contains integer constants and variables. The T, CD, TW, and CT arrays are used for storage of calculated data; each array is organized into data sets arranged either for the data requirements of downstream overlays or the storage requirements for the subroutines within that overlay. Core maps for these arrays can be found in Sections III through V.

MODULE/OVERLAY DATA REQUIREMENTS

The primary method of data transmission from overlay to overlay is through blank common. Mass storage file records are only used to transmit computed data that cannot be saved in blank common.

Blank Common Initialization

The procedure used to load overlays into core for execution uses the PPLØADER, which is in the blank common region during the loading of overlay subprograms. The contents of blank common are saved by the exiting overlay program by the BUFFER ØUT instruction. Blank common is reset by the incoming overlay program by the BUFFER IN instruction. File TAPE24 is used as the storage medium for blank common.

Table 3. OVERLAY BLANK COMMON REQUIREMENTS

Blank Common Location	Basic Array Name	Overlay							
		(8,0)	(14,0)	(15,0)	(16,0)	(9,0)	(10,0)	(18,0)	(17,0)
1-2060	T	2,060	2,060	2,060	2,060	2,060	2,060	2,060	2,060
2061-4120	D	2,060	2,060	2,060	2,060	2,060	2,060	2,060	2,060
4121-6121	CD	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
6121-6220	ND	100	100	100	100	100	100	100	100
6221-7120	TW	900	900	900	900	900	900	900	900
7121-9168	CT	-	-	-	-	-	-	2,048	-
Total Cells		7,120	7,120	7,120	7,120	7,120	7,120	9,168	7,120

Input Data

Input data for the wing and empennage module consist of the following:

1. Variable data for each surface which are input through input data decks WING, HORIZONTAL, and VERTICAL, Data from these decks are merged into the data sets containing default values for each surface. These defaults are initialized from the SWEEP permanent data bank.

2. Design variables computed by previously executed SWEEP modules - the data management and the flutter and temperature modules. Subroutine CCNTL, overlay (8,0), processes the appropriate surface data, stored on mass storage file 1, records 21 and 38, into the D array before problem execution.

3. Program constants for airfoil cross-section and flutter analysis, data values from the SWEEP permanent data bank, stored on records 36 and 37, mass storage file 1.

4. Material properties for metallic designs, contained in the material properties library of the SWEEP permanent data bank. Library information is obtained as required from records 41 through 60 of mass storage file 1.

5. Execution and design information stored in SWEEP labeled common blocks MISC and IPRINT.

Output Data

The primary output of the wing and empennage module consists of group weight and balance results for the surface being analyzed. The computed data required by SWEEP module output, overlay (13,0), are stored in array FDAT, labeled common block FDATT. Computed weights for each surface are also summarized and printed by subroutine WØDATA, overlay (17,0). The primary weight summary data for each surface are shown in Figures 10 through 12.

Data for input to the stand-alone Flexible Load Analysis Program and Flutter Optimization Program are output as punched output on data cards or as printed output.

Mass Storage File Records

Mass storage file records used by the wing and empennage module are listed in Table 4. Pertinent information for each record is presented in this table.

```
CASE    1                     WEIGHT SUMMARY.                                          ** PRTD **
               -***-TOTAL WING              STIFFENEL SKIN/MULTI-RIB-***-
C 141 TEST CASE FOR NEW WING PROGRAM CHECKOUT     AUGUST 1972
C 141 TEST CASE               ---NO. 1 ---
```

-****-TOTAL WEIGHT SUMMARY-****-

	WEIGHT--LB/AV			*UNIT WEIGHT--LB/SF*			*C.G.--RP*			*C.G.--FS*			*AREA*
	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	SF/AV
TOTAL	0.0	32045.8	0.0	0.0	10.67	0.0	0.0	371.6	0.0	0.0	951.7	0.0	3002.5
O-PNL	0.0	29611.6	0.0	0.0	11.10	0.0	0.0	399.0	0.0	0.0	963.9	0.0	2667.6
C-SEC	0.0	2434.2	0.0	0.0	10.07	0.0	0.0	36.8	0.0	0.0	803.1	0.0	241.7
PIVOT	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	

-**-OUTER PANEL COMPONENTS-**-

/T-BOX/	0.0	21614.0	0.0	0.0	15.98	0.0	0.0	391.2	0.0	0.0	942.7	0.0	1352.6
/L.E. /	0.0	1399.8	0.0	0.0	4.44	0.0	0.0	453.6	0.0	0.0	899.6	0.0	315.2
/T.E. /	0.0	5835.8	0.0	0.0	5.28	0.0	0.0	411.6	0.0	0.0	1056.7	0.0	1105.9
/TIP /	0.0	39.9	0.0	0.0	0.97	0.0	0.0	947.4	0.0	0.0	1203.8	0.0	41.2
/MISC./	0.0	722.2	0.0	0.0	0.27	0.0	0.0	391.3	0.0	0.0	942.7	0.0	2667.6
(AV.E.)	0.0	3834.3	0.0										
(+FTG)	0.0	28.0	0.0										

```
TOGW(1)=   0.0 TOGW(2)= 316100.0 TOGW(3)=    0.0  +NZ= 2.500 +NZG= 0.0   FL(TOT)=116940.0  MATL NO=  6
DGW(1)=    0.0  DGW(2)= 316100.0  DGW(3)=    0.0  -NZ= 1.000 -NZG= 0.0   FL(DFS)=116939.9  YCP=  418.6
```

Figure 10. Weight summary, wing group.

CASE 1

-***-NOMINAL TORQUE-BOX DETAIL WEIGHTS-***-

** PRTD - IP(37) **

	-**-TOTAL SURFACE-**-			-**-OUTER PANEL-**-			-**-CENTER-SECTION-**-		
	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)
TORQUE-BOX	0.0	24046.1	0.0	0.0	21614.0	0.0	0.0	2434.2	0.0
UPPER COVER	0.0	8853.1	0.0	0.0	7942.2	0.0	0.0	911.0	0.0
SKINS	0.0	5694.6	0.0	0.0	5158.2	0.0	0.0	536.3	0.0
STRG.	0.0	2642.5	0.0	0.0	2285.5	0.0	0.0	357.0	0.0
MISC. SK.	0.0	516.0	0.0	0.0	500.4	0.0	0.0	15.6	0.0
LOWER COVER	0.0	7793.1	0.0	0.0	7124.2	0.0	0.0	668.9	0.0
SKINS	0.0	5306.8	0.0	0.0	4903.4	0.0	0.0	403.4	0.0
STRG.	0.0	1960.9	0.0	0.0	1693.4	0.0	0.0	267.5	0.0
MISC. SK.	0.0	545.4	0.0	0.0	527.3	0.0	0.0	18.1	0.0
RIBS	0.0	4492.0	0.0	0.0	3944.6	0.0	0.0	547.4	0.0
INTERM.	0.0	2615.7	0.0	0.0	2406.1	0.0	0.0	209.5	0.0
BULKHEADS	0.0	933.4	0.0	0.0	933.4	0.0	0.0	0.0	0.0
RT/C-L	0.0	942.9	0.0	0.0	605.0	0.0	0.0	337.9	0.0
FRONT SPAR	0.0	1068.5	0.0	0.0	967.3	0.0	0.0	101.2	0.0
CAPS	0.0	132.7	0.0	0.0	123.2	0.0	0.0	9.5	0.0
WEB	0.0	935.8	0.0	0.0	844.1	0.0	0.0	91.8	0.0
REAR SPAR	0.0	1324.1	0.0	0.0	1245.3	0.0	0.0	78.8	0.0
CAPS	0.0	150.9	0.0	0.0	140.2	0.0	0.0	10.6	0.0
WEB	0.0	1173.3	0.0	0.0	1105.1	0.0	0.0	68.2	0.0
MISC. ATT.	0.0	409.9	0.0	0.0	362.5	0.0	0.0	47.4	0.0
STORE FTG.	0.0	28.0	0.0	0.0	28.0	0.0			

	-**-LEADING EDGE-**-				-**-TRAILING EDGE-**-		
FIXED STR	0.0	139.8	0.0	*FIXED STR*	0.0	1952.5	0.0
DEV. NO. 1	0.0	0.0	0.0	*T.E. FLAPS*	0.0	2414.7	0.0
DEV. NO. 2	0.0	0.0	0.0	*SPOILERS*	0.0	725.3	0.0
DEV. NO. 3	0.0	0.0	0.0	*AILERONS*	0.0	743.3	0.0

-**-FLUTTER STIFFNESS SUMMARY--OUTER-PANEL-**-

	UPPER COVER			LOWER COVER			RIBS, SPARS, ATT.		
CON-U./-L.//I.R.	0.0	1283.4	0.0	0.0	2068.9	0.0	0.0	0.0	0.0
SK.-U./-L.//F.S.	0.0	1135.8	0.0	0.0	1933.3	0.0	0.0	234.3	0.0
STR-U./-L.//R.S.	0.0	147.6	0.0	0.0	75.2	0.0	0.0	301.5	0.0
M.SK.-U/-L//M.A.	0.0	0.0	0.0	0.0	0.4	0.0	0.0	6.3	0.0

Figure 10. Weight summary, wing group (concl).

```
CASE    1                       WEIGHT SUMMARY.                                                         ** PRTD **
        -***-TOTAL HORI TAIL                        STIFFENED SKIN/MULTI-RIB-***-
C 141 TEST CASE FOR NEW WING PROGRAM CHECKOUT      AUGUST 1973
C 141 TEST CASE                ---NO. 1 ---

                                    -****-TOTAL WEIGHT SUMMARY-****-
                  *WEIGHT--LB//V*         *UNIT WEIGHT--LB/SF*      *C.G.--BP*                 *C.G.--FS*          *AREA*
                GW(1)   GW(2)   GW(3)   GW(1) GW(2) GW(3)    GW(1)  GW(2)   GW(3)    GW(1)  GW(2)   GW(3)    SF/AV
***TOTAL***      0.0  2330.1     0.0    0.0   4.82  0.0       0.0  109.7    0.0      0.0 1842.5    0.0      483.0
  *O-PNL*        0.0  2330.1     0.0    0.0   4.82  0.0       0.0  109.7    0.0      0.0 1842.5    0.0      483.0
  *C-SFC*        0.0     0.0     0.0    0.0   0.0   0.0       0.0    0.0    0.0      0.0    0.0    0.0        1.0
  *PIVOT*        0.0     0.0     0.0                          0.0    0.0    0.0      0.0    0.0    0.0

                                     -**-OUTER PANEL COMPONENTS-**-
  /T-BOX/        0.0  1619.2     0.0    0.0   6.70  0.0       0.0  102.6    0.0      0.0 1828.9    0.0      238.2
  /L.E. /        0.0   117.1     0.0    0.0   1.64  0.0       0.0  125.5    0.0      0.0 1799.4    0.0       71.4
  /T.E. /        0.0   541.6     0.0    0.0   3.25  0.0       0.0  125.9    0.0      0.0 1893.0    0.0      166.7
  /TIP  /        0.0    10.2     0.0    0.0  [illegible].93  0.0       0.0  297.9    0.0      0.0 1915.0    0.0        6.7
  /MISC./        0.0    41.7     0.0    0.0   0.09  0.0       0.0  102.6    0.0      0.0 1828.9    0.0      483.0
  (+V.F.)        0.0     0.0     0.0
  (+FTG )        0.0     0.0     0.0

 TGW(1)=        0.0 TGW(2)= 131100.0 TGW(3)=      0.0  +NZ= 2.500 +NZG= 0.0    FL(TOT)=     0.0  MAIL NO= 4
 DGW(1)=        0.0 DGW(2)= 131100.0 DGW(3)=      0.0  -NZ= 1.000 -NZG= 0.0    FL(DES)=     0.0  YCP=     0.0
```

Figure 11. Weight summary, horizontal tail group.

CASE 1 —***-NOMINAL TORQUE-BOX DETAIL WEIGHTS-***— ** PRTF - 1P(37) **

	-**-TOTAL SURFACE-**-			-**-OUTER PANEL-**-			-**-CENTER-SECTION-**-		
	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)
TORQUE-BOX	0.0	1619.2	0.0	0.0	1619.2	0.0	0.0	0.0	0.0
UPPER COVER	0.0	617.6	0.0	0.0	617.6	0.0	0.0	0.0	0.0
SKINS	0.0	417.3	0.0	0.0	417.3	0.0	0.0	0.0	0.0
STRG.	0.0	174.5	0.0	0.0	174.5	0.0	0.0	0.0	0.0
MISC. SK.	0.0	25.8	0.0	0.0	25.8	0.0	0.0	0.0	0.0
LOWER COVER	0.0	466.0	0.0	0.0	466.0	0.0	0.0	0.0	0.0
SKINS	0.0	308.3	0.0	0.0	308.3	0.0	0.0	0.0	0.0
STRG.	0.0	130.1	0.0	0.0	130.1	0.0	0.0	0.0	0.0
MISC. SK.	0.0	27.5	0.0	0.0	27.5	0.0	0.0	0.0	0.0
RIBS	0.0	297.7	0.0	0.0	297.7	0.0	0.0	0.0	0.0
INTERM.	0.0	212.8	0.0	0.0	212.8	0.0	0.0	0.0	0.0
BULKHEADS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RT/C-L	0.0	85.0	0.0	0.0	85.0	0.0	0.0	0.0	0.0
FRONT SPAR	0.0	103.3	0.0	0.0	103.3	0.0	0.0	0.0	0.0
CAPS	0.0	28.7	0.0	0.0	28.7	0.0	0.0	0.0	0.0
WEB	0.0	74.6	0.0	0.0	74.6	0.0	0.0	0.0	0.0
REAR SPAR	0.0	115.9	0.0	0.0	115.9	0.0	0.0	0.0	0.0
CAPS	0.0	33.2	0.0	0.0	33.2	0.0	0.0	0.0	0.0
WEB	0.0	82.8	0.0	0.0	82.8	0.0	0.0	0.0	0.0
MISC. ATT.	0.0	18.7	0.0	0.0	18.7	0.0	0.0	0.0	0.0
STORE FTG.	0.0	0.0	0.0	0.0	0.0	0.0			

	-**-LEADING EDGE-**-		
FIXED STR	0.0	117.1	0.0

	-**-TRAILING EDGE-**-		
FIXED STR	0.0	23.3	0.0
ELEVATORS	0.0	518.6	0.0

Figure 11. Weight summary, horizontal tail group (concl).

```
 CASE    1                        WEIGHT SUMMARY.                                                        ** PRTD **
                -***-TOTAL VERT TAIL                      STIFFENED SKIN/MULTI-RIB-***-
C 141 TEST CASE FOR NEW WING PROGRAM CHECKOUT     AUGUST 1973
C 141 TEST CASE                   ---NO. 1 ---

                                              -****-TOTAL WEIGHT SUMMARY-****-
                  *WEIGHT--LB/AV*           *UNIT WEIGHT--LB/SF*       *C.G.--FP*                 *C.G.--FS*              *AREA*
                GW(1)   GW(2)    GW(3)     GW(1)  GW(2)  GW(3)     GW(1)  GW(2)   GW(3)     GW(1)   GW(2)   GW(3)     SF/AV
***TOTAL***      0.0   2104.1     0.0       0.0   5.06   0.0        0.0   106.3    0.0       0.0   1739.5    0.0     416.0
  *O-PNL*        0.0   2104.1     0.0       0.0   5.06   0.0        0.0   106.3    0.0       0.0   1739.5    0.0     416.0
  *C-SEC*        0.0      0.0     0.0       0.0   0.0    0.0        0.0     0.0    0.0       0.0      0.0    0.0       1.0
  *PIVOT*        0.0      0.0     0.0                               0.0     0.0    0.0       0.0      0.0    0.0

                                             -**-OUTER PANEL COMPONENTS-**-
 /T-BOX/         0.0   1613.6     0.0       0.0   7.91   0.0        0.0   102.5    0.0       0.0   1722.4    0.0     204.0
 /L.E. /         0.0     83.2     0.0       0.0   1.36   0.0        0.0   122.5    0.0       0.0   1663.6    0.0      61.2
 /T.E. /         0.0    336.7     0.0       0.0   2.37   0.0        0.0   117.4    0.0       0.0   1640.6    0.0     142.6
 /TIP  /         0.0      7.3     0.0       0.0   0.92   0.0        0.0   268.5    0.0       0.0   1643.3    0.0       7.9
 /MISC./         0.0     61.3     0.0       0.0   0.15   0.0        0.0   102.5    0.0       0.0   1722.4    0.0     416.0
 (+V.F.)         0.0      0.0     0.0
 (+FTG )         0.0      0.0     0.0

 TOGW(1)=       0.0 TOGW(2)= 316100.0 TOGW(3)=      0.0  +NZ= 0.001 +NZG= 0.0    FL(TOT)=     0.0  MATL NC=  6
  DGW(1)=       0.0  DGW(2)= 316100.0  DGW(3)=      0.0  -NZ= 1.000 -NZG= 0.0    FL(DES)=     0.0  YCP=    0.0
```


Figure 12. Weight summary, vertical tail group.

CASE 1	-***-NOMINAL TORQUE-BOX DETAIL WEIGHTS-***-						** PRTD - IP(37) *		
	-**-TOTAL SURFACE-**-			-**-OUTER PANEL-**-			-**-CENTER-SECTION-**-		
	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)
TORQUE-BOX	0.0	1613.6	0.0	0.0	1613.6	0.0	0.0	0.0	0.0
UPPER COVER	0.0	410.0	0.0	0.0	410.0	0.0	0.0	0.0	0.0
SKINS	0.0	264.8	0.0	0.0	264.8	0.0	0.0	0.0	0.0
STRG.	0.0	125.6	0.0	0.0	125.6	0.0	0.0	0.0	0.0
MISC. SR.	0.0	19.6	0.0	0.0	19.6	0.0	0.0	0.0	0.0
LOWER COVER	0.0	407.6	0.0	0.0	407.6	0.0	0.0	0.0	0.0
SKINS	0.0	263.6	0.0	0.0	263.6	0.0	0.0	0.0	0.0
STRG.	0.0	124.4	0.0	0.0	124.4	0.0	0.0	0.0	0.0
MISC. SR.	0.0	19.5	0.0	0.0	19.5	0.0	0.0	0.0	0.0
RIBS	0.0	536.7	0.0	0.0	536.7	0.0	0.0	0.0	0.0
INTERM.	0.0	379.5	0.0	0.0	379.5	0.0	0.0	0.0	0.0
BULKHEADS	0.0	33.5	0.0	0.0	33.5	0.0	0.0	0.0	0.0
RT/C-L	0.0	123.8	0.0	0.0	123.8	0.0	0.0	0.0	0.0
FRONT SPAR	0.0	108.1	0.0	0.0	108.1	0.0	0.0	0.0	0.0
CAPS	0.0	14.4	0.0	0.0	14.4	0.0	0.0	0.0	0.0
WEB	0.0	93.6	0.0	0.0	93.6	0.0	0.0	0.0	0.0
REAR SPAR	0.0	123.2	0.0	0.0	123.2	0.0	0.0	0.0	0.0
CAPS	0.0	16.7	0.0	0.0	16.7	0.0	0.0	0.0	0.0
WEB	0.0	106.6	0.0	0.0	106.6	0.0	0.0	0.0	0.0
MISC. ATT.	0.0	26.1	0.0	0.0	26.1	0.0	0.0	0.0	0.0
STORE FTG.	0.0	0.0	0.0	0.0	0.0	0.0			

	-**-LEADING EDGE-**-				-**-TRAILING EDGE-**-		
FIXED STR	0.0	[illegible]	0.0	*FIXED STR*	0.0	67.2	0.0
				RUDDERS	0.0	271.5	0.0

Figure 12. Weight summary, vertical tail group (concl).

TABLE 4. MASS STORAGE FILE 1 RECORDS, WING AND EMPENNAGE MODULE

Rcd No.	Size	Write			Read			Table Ref for Array Data	Description
		Array (Initial Loc)	Subr	Overlay	Array (Initial Loc)	Subr	Overlay		
10	200	TGJ(1)	GEØMW	(8, 0)	TGJ(1)	GJCAL	(16, 0)	36	Flutter analysis data
13	400	CD(1)	ACPRØG	(18, 0)	-	-	-	217	Stiffness data, GW1, adv comp design
14	400	CD(1)	ACPRØG	(18, 0)	CD(1401)	WVFDD	(17, 0)	217	Stiffness data, GW2, adv comp design
15	400	CD(1)	ACPRØG	(18, 0)	-	-	-	217	Stiffness data, GW3, adv comp design
17	264	RATIØ(1)	WHVNET	(2, 0)	RATIØ(1)	ALØAD	(16, 0)	-	Correctim factors, design loads
21	200	WD(1)	DCCNTL	(2, 0)	WD(1)	CCNTL	(8, 0)	20	Wing and empennage design data
22	195	BC(1)	DATAIN	(2, 0)	BC(1)	WFLDD	(17, 0)	-	Air vehicle design data
23	2060	D(1)	READ	(1, 0)	D(1)	CCNTL	(8, 0)	8	Variable data, wing
26	2060	D(1)	READ	(1, 0)	D(1)	CCNTL	(8, 0)	8	Variable data, horizontal tail
27	2060	D(1)	READ	(1, 0)	D(1)	CCNTL	(8, 0)	8	Variable data, vertical tail

TABLE 4. MASS STORAGE FILE 1 RECORDS, WING AND EMPENNAGE MODULE (CONT)

Rcd No.	Size	Write			Read			Table Ref for Array Data	Description
		Array (Initial Loc)	Subr	Overlay	Array (Initial Loc)	Subr	Overlay		
30	900	ACL(1)	ACLØAD	(18, 0)	ACL(1)	AVLØAD	(18, 0)	196	Design loads data, adv comp design
32	198	DUM(1)	WHVNET	(4, 0)	SLD(1)	ALØAD	(16, 0)	-	Design awloads, V, M, T, for wing and empennage
36	500	D(500)	READ	(1, 0)	DAF(1)	GEØMW	(8, 0)	25	Airfoil cross-section data, permanent data bank
37	100	D(1)	READ	(1, 0)	GJDAT(1)	GJTT	(16, 0)	-	T-tail, vertical tail, flutter analysis data, permanent data bank
38	50	SPAL(1) SPAL(1) DUMMY(1)	DWHQQ WHVQQ WDDATA	(2, 0) (3, 0) (17, 0)	DUMMY(1) T(1001)	WØDATA CCNTL	(17, 0) (8, 0)	21	Flutter analysis design data, wing and empennage
39	132	RLDS(1)	ACPRØG	(18, 0)	RLDS(1)	ACPRØG	(18, 0)	-	Temporary storage, design load correction factors, adv comp design
40	400	CD(1)	ACNSTR	(18, 0)	CD(1) CD(1)	ACPRTA ACNSTR	(18, 0) (18, 0)	217	Temporary storage, torque-box, stiffness data, adv comp design

TABLE 4. MASS STORAGE FILE 1 RECORDS, WING AND EMPENNAGE MODULE (CONT)

Rcd No.	Size	Write			Read			Table Ref for Array Data	Description
		Array (Initial Loc)	Subr	Overlay	Array (Initial Loc)	Subr	Overlay		
41-60	300	TMF(1) TND(1)	READ FTGCTL	(1, 0) (5, 0)	TMD(1)	MTLCW	(16, 0)	-	Material properties library, permanent data bank, codes 1-20
118	150	CD(1) TSC(1)	PRØG CNSTR	(9, 0) (10, 0)	TSC(1) TSC(1)	PRØG TBØPT	(9, 0) (9, 0)	-	Temporary storage, torque-base design data block 1, search point 1
119	150	CD(1) TWT(1)	PRØG CNSTR	(9, 0) (10, 0)	TWT(1)	TBØPT	(9, 0)	-	Temporary storage, torque-box design data block 2, search point 1
120	100	CD(1) TSS(1)	PRØG CNSTR	(9, 0) (10, 0)	TSC(1)	TBØPT	(9, 0)	-	Temporary storage, torque-box design data, block 3, search point 1
121	340	CD(1) TC(1)	PRØG CNSTR	(9, 0) (10, 0)	TC(1)	TBØPT	(9, 0)	-	Temporary storage, torque-box design data, block 4, search point 1
122	400	CD(1) CD(1)	PRØG CNSTR	(9, 0) (10, 0)	CD(1)	TBØPT	(9, 0)	-	Temporary storage, torque-box design data, block 5, search point 1
123-127	-	-	-	-	-	-	-	-	Blocks 1-5, search point 2, same as 118-122

TABLE 4. MASS STORAGE FILE 1 RECORDS, WING AND EMPENNAGE MODULE (CONT)

Rcd No.	Size	Write			Read			Table Ref for Array Data	Description
		Array (Initial Loc)	Subr	Overlay	Array (Initial Loc)	Subr	Overlay		
128-132	-	-	-	-	-	-	-	-	Blocks 1-5, search point 3, same as 118-122
133-137	-	-	-	-	-	-	-	-	Blocks 1-5, search point 4, same as 118-122
138-142	-	-	-	-	-	-	-	-	Blocks 1-5, search point 5, same as 118-122
143	200	TSC(1)	PRØG	(9, 0)	TSC(1)	PRØG	(9, 0)	-	Temporary storage, design data for gross weight change
144	200	YC(1)	CASE	(8, 0)	TG(1)	WØDATA	(17, 0)	38, 168	Geometry data for aero and structural chord calculations
145	135	TGA(1)	WCØNT	(15, 0)	TGA(1)	WØDATA	(17, 0)	167	Geometry data for mass distribution calculations
146	300	TG(1)	WCØNT	(15, 0)	TG(1)	WØDATA	(17, 0)	166	Geometry data for mass distribution calculations
147	400	TWG(1)	WCØNT	(15, 0)	TWG(1)	WØDATA	(17, 0)	169	Weight distribution and inertia loads data

TABLE 4. MASS STORAGE FILE 1 RECORDS, WING AND EMPENNAGE MODULE (CONT)

Rcd No.	Size	Write			Read			Table Ref for Array Data	Description
		Array (Initial Loc)	Subr	Overlay	Array (Initial Loc)	Subr	Overlay		
148	50	CCW(1)	WCØNT	(15, 0)	CCW(1)	WØDATA	(17, 0)	170	Weight summary data, leading and trailing edge structures
149	150	CLEI(1)	WLETE	(14, 0)	CLEI(1) CLEI(1)	WØDATA WØDATA	(16, 0) (17, 0)	174	Calculated mass distribution data, leading edge structures
150	150	CTEI(1)	WLETE	(14, 0)	CTEI(1) CTEI(1)	WØDATA WØDATA	(16, 0) (17, 0)	174	Calculated mass distribution data, trailing edge structures
151	150	CFL1I(1)	WCØNT	(15, 0)	CFL1I(1)	WØDATA	(17, 0)	187	Calculated mass distribution data, fuel cell 1
152	150	CFL2I(1)	WCØNT	(15, 0)	CFL2I(1)	WØDATA	(17, 0)	187	Calculated mass distribution data, fuel cell 2
153	150	CMII(1)	WCØNT	(15, 0)	CMII(1)	WØDATA	(17, 0)	185	Calculated mass distribution data, miscellaneous contents and structures
154	150	CCDLI(1)	WCØNT	(15, 0)	CCDLI(1)	WØDATA	(17, 0)	186	Calculated mass distribution data, concentrated mass items

TABLE 4. MASS STORAGE FILE 1 RECORDS, WING AND EMPENNAGE MODULE (CONT)

Rcd No.	Size	Write			Read			Table Ref for Array Data	Description
		Array (Initial Loc)	Subr	Overlay	Array (Initial Loc)	Subr	Overlay		
155	150	TCS(1)	WØDATA	(17, 0)	CTBI(1)	WØDATA	(17, 0)	-	Calculated mass distribution data, torque-box structures
156	150	CTBW(1) CTBW(1)	PRØG ACPRØG	(9, 0) (18, 0)	CTBW(1)	WØDATA	(17, 0)	193	Calculated torque-box structure data, GW 1
157	150	CTBW(1) CTBW(1)	PRØG ACPRØG	(9, 0) (18, 0)	CTBW(1)	WØDATA	(17, 0)	193	Calculated torque-box structure data, GW 2
158	150	CTBW(1) CTBW(1)	PRØG ACPRØG	(9, 0) (18, 0)	CTBW(1)	WØDATA	(17, 0)	193	Calculated torque-box structure data, GW 3
159	24	WHVLID(1)	MAXLDS	(4, 0)	WHVLID(1)	ACLØAD	(18, 0)	-	Load condition indicators
160-183	200	BØ(1)	MAXLDS	(4, 0)	WBØ(1)	ACLØAD	(18, 0)	-	Design airloads data for wing and empennage, SWEEP load conditions 1-24
184	100	CD(1) TSS(1) CD(1) TSS(1)	PRØG TBØPT ACPRØG ATBØPT	(9, 0) (9, 0) (18, 0) (18, 0)	CD(400)	WØDATA	(17, 0)	236	Weight summary data, wing and empennage exposed panel structures, GW 1

TABLE 4. MASS STORAGE FILE 1 RECORDS, WING AND EMPENNAGE MODULE (CONCL)

Rcd No.	Size	Write			Read			Table Ref for Array Data	Description
		Array (Initial Loc)	Subr	Overlay	Array (Initial Loc)	Subr	Overlay		
185	100	CD(1) TSS(1) CD(1) TSS(1)	PRØG TBØPT ACPRØG ATBØPT	(9, 0) (9, 0) (18, 0) (18, 0)	CD(500)	WØDATA	(17, 0)	236	Weight summary data, wing and empennage exposed panel structures, GW 2
186	100	CD(1) TSS(1) CD(1) TSS(1)	PRØG TBØPT ACPRØG ATBØPT	(9, 0) (9, 0) (18, 0) (18, 0)	CD(600)	WØDATA	(17, 0)	236	Weight summary data, wing and empennage exposed panel structures, GW 3
187	100	CD(1) TSS(1) CD(1) TSS(1)	PRØG TBØPT ACPRØG ATBØPT	(9, 0) (9, 0) (18, 0) (18, 0)	CD(800)	WØDATA	(17, 0)	236	Weight summary data, pivot and center-section structures, GW 1
188	100	CD(1) TSS(1) CD(1) TSS(1)	PRØG TBØPT ACPRØG ATBØPT	(9, 0) (9, 0) (18, 0) (18, 0)	CD(900)	WØDATA	(17, 0)	236	Weight summary data, pivot and center-section structures, GW 2
189	100	CD(1) TSS(1) CD(1) TSS(1)	PRØG TBØPT ACPRØG ATBØPT	(9, 0) (9, 0) (18, 0) (18, 0)	CD(1000)	WØDATA	(17, 0)	236	Weight summary data, pivot and center-section structures, GW 3
190	150	CIØY(1) CCI(1)	WDDATA WØDATA	(16, 0) (17, 0)	CCI(1) CIØY(1)	WØDATA WØDATA	(17, 0) (17, 0)	175	Calculated mass distribution data for yaw inertia

MODULE CORE MAPS

Labeled Common Arrays

Core maps for labeled common arrays FDAT, XMISC, and IP can be found in Tables 5 through 7. Array FDAT is used only by subroutine PRTD, overlay (17,0). Arrays XMISC and IP are used by all module overlays.

Blank Common Arrays

Core maps for variable-data array D and integer constants array ND are presented in Tables 8 and 9. Table 10 contains the core map for array DC, a subarray of array D, used primarily to store program constants. Tables 11 and 12 contain subroutine reference information for array D, Table 11 is based on numerical order of the D array data cells, and Table 12 by alphabetical order of variable names assigned to array D. Subroutine reference information for arrays ND and DC are presented in Tables 13 and 14.

TABLE 5. FDAT ARRAY, FINAL OUTPUT DATA

General information for array FDAT:

Core location = Labeled common block FDATT
Array size = 60 cells
Calculated weights for wing and empennage structure are stored in FDAT array by subroutine PRTD, overlay (17, 0) in locations 1-30. Weight information is organized into group weight statement type breakdown.
Locations 31-60 are used by overlays (6, 0), (7, 0), and (12, 0) to store calculated weight data for other structure groups.

Array Location	Description
	Locations 1-14 contain wing group weight data
1	W_W, total wing structure, lb per A/V
2	X_{CG}, X-coordinate for total wing structure CG, fuselage station
3	$W_{C\text{-}SEC}$, basis structure, center section, lb per A/V
4	W_{PIVOT}, basic structure, pivot, lb per A/V
5	W_{OPNL}, basic structure, outer panel, lb per A/V
6	W_{AIL}, ailerons, lb per A/V
7	W_{FTE}, flaps, trailing edge, lb per A/V
8	W_{FLE}, flaps, leading edge, lb per A/V
9	W_{SLATS}, slats, lb per A/V
10	W_{SP}, spoilers, lb per A/V
11	W_{MISC}, secondary structures, lb per A/V
12	W_{TIP}, basic structure, tips, lb per A/V
13	Not used
14	Not used
	Locations 15-22 contain horizontal tail group weight data
15	W_{HT}, total horizontal tail structure, lb per A/V
16	X_{CG}, X-coordinate for total horizontal tail structure CG, fuselage station
17	$W_{C\text{-}SEC}$, basic structure, center section/spindle, lb per A/V
18	W_{OPNL}, basic structure, outer panel, lb per A/V
19	W_{ELEV}, elevator, lb per A/V
20	W_{MISC}, secondary structures, lb per A/V
21	Not used
22	Not used

TABLE 5. FDAT ARRAY, FINAL OUTPUT DATA (CONCL)

Array Location	Description
	Locations 23-30 contain vertical tail group weight data
23	W_{VT}, total vertical tail structure, lb per A/V
24	X_{CG}, X-coordinate for total vertical tail structure CG, fuselage station
25	W_{C-SEC}, basic structure, center-section/spindle, lb per A/V
26	W_{OPNL}, basic structure, outer panel, lb per A/V
27	W_{RUD}, rudder, lb per A/V
28	W_{MISC}, secondary structures, lb per A/V
29	Not used
30	Not used
31-60	Used by landing gear, air induction system, and fuselage modules

TABLE 6. XMISC ARRAY

General information for array XMISC:

Core location = labeled common block MISC.

Array size = 100 cells.

Data type: Real in locations 1-69
Alphanumeric in locations 70-100

Array contains case control information and computed design data.

Only the locations pertaining to the wing and empennage module are defined in this table. Definitions for the other locations can be found in Table 9, Volume II.

Array Loc	Defined		Used		Description
	Routine	Overlay	Routine	Overlay	
1	READ	(1,0)	CCNTL MFCNTL	(8,0) (11,0)	Number of arrays of material properties in mass storage in records 41-60
2	ØLAY00	(0,0)	CCNTL ALØAD	(8,0) (16,0)	Component indicator for wing and empennage module 1 = wing 2 = horizontal tail 3 = vertical tail
3	ØLAY00 PRØG	(0,0) (9,0)	ØLAY00	(0,0)	Logic control code, for execution of wing and empennage module overlays, (9,0), (10,0), and (17,0) metal designs. Defines overlay to be executed on return of control from overlay (9,0) to overlay (0,0): 0.0 = execute overlay (10,0) 1.0 = execute overlay (17,0) Initialized at 0.0 by program ØLAY00 and set to 1.0 by PRØG, overlay (9,0) at conclusion of torque box analysis.

TABLE 6. XMISC ARRAY (CONT)

Array Loc	Defined		Used		Description
	Routine	Overlay	Routine	Overlay	
4	ØLAY00	(0,0)	READ CCNTL	(1,0) (8,0)	Case number
5	WHVQQ	(3,0)	CCNTL	(8,0)	Dynamic pressure for wing flutter design, lb/ft^2
6	WHVQQ	(3,0)	CCNTL	(8,0)	Dynamic pressure for vertical tail flutter design, lb/ft^2
7	WHVQQ	(3,0)	CCNTL	(8,0)	Dynamic pressure for horizontal tail flutter design, lb/ft^2
8	WHVNET	(4,0)	CCNTL	(8,0)	Wing design (reference) temperature, $^\circ$ F
9	WHVNET	(4,0)	CCNTL	(8,0)	Vertical tail design (reference) temperature, $^\circ$ F
10	WHVNET	(4,0)	CCNTL	(8,0)	Horizontal tail design (reference) temperature, $^\circ$ F
26	WHVGEØ	(2,0)	CCNTL	(8,0)	Sweep of wing quarter-chord (forward position variable-sweep only), deg
28	WHVQQ	(3,0)	CCNTL	(8,0)	Wing structural material shear modulus at design flutter point, $lb/in.^2$
29	WHVQQ	(3,0)	CCNTL	(8,0)	Horizontal tail structural material shear modulus at design flutter point, $lb/in.^2$
30	WHVQQ	(3,0)	CCNTL	(8,0)	Vertical tail structural material shear modulus at design flutter point, $lb/in.^2$

TABLE 6. XMISC ARRAY (CONT)

Array Loc	Defined		Used		Description
	Routine	Overlay	Routine	Overlay	
39	ØLAY00 PRØG TBØPT	(0,0) (9,0) (9,0)	PRØG TBØPT	(9,0) (9,0)	Logic control code for execution of wing and empennage module overlays (9,0) and (10,0), metallic designs. Code value of 0.0 through 7.0 determine the logic path to be executed in subroutines PRØG and TBØPT, overlay (9,0), after return of control from subroutine CNSTR, overlay (10,0): 0.0 = initial call to subroutine PRØG from program ØLAY9 and to subroutine TBØPT from subroutine PRØG during the deadweight iteration passes. 1.0 - 6.0 = return code for subroutines PRØG and TBØPT. Identifies logic status and call statement to subroutine CNSTR of overlay (10,0) from subroutine TBØPT, overlay (9,0). Code values used by PRØG and TBØPT to determine continuation path. 7.0 = Normal return to subroutine PRØG from TBØPT. Initialized at 0.0 by program ØLAY00 and subroutine PRØG. Status code values specified by subroutine TBØPT.

TABLE 6. XMISC ARRAY (CONCL)

Array Loc	Defined		Used		Description
	Routine	Overlay	Routine	Overlay	
42	WHVNET	(4,0)	VLØAD VLØAD1	(9,0) (16,0)	Indicator to designate that horizontal tail loads have been reversed 0.0 = loads have not been reversed 1.0 = loads have been reversed
85-100	READ	(1,0)	CCNTL PRTG PRTA PRTH PRTB PRTC WLETE PRTD ACPRTA PRTB PRTC PRTH	(8,0) (8,0) (9,0) (9,0) (10,0) (10,0) (14,0) (17,0) (18,0) (18,0) (18,0) (18,0)	Case title, and image of case title cards 1 and 2. Locations 85-100 assigned array name R, (size = 16 cells).

TABLE 7. IP ARRAY, PRINT CONTROL DATA

General information for array IP:

Core location = Labeled common block IPRINT
Array size = 80 cells
Data type = Integers
Array contains card image information from case control card 1, columns 1-80.
Code values in each location control printing of data by indicated subroutines (sample output can be found in Appendix A, Volume IX, User's Manual). Code value 0 indicates print; 1 indicates no printing.
Locations identified with an asterisk (*) indicate controls for related data printed under control of other SWEEP modules.
Indicated names are for printing subroutines; names in brackets identifies subroutine where print control tests are made.
Array information is used for each execution of module during a given case; thus, printed output for executed wing and empennage problems will be the same.

Array Location	Printing Subroutine	Overlay	Description
1*	READ	(1, 0)	Permanent data, first case only
2*	READ	(1, 0)	Current case variable data
3	CONTL	(8, 0)	Variable data arrays: 1. Output of initial status of D array locations subject to revision with design data transferred through WP, SPAL, and XMISC arrays 2. Output of WD array 3. Output of complete D array 4. Output of SPAL array
4	GEØMC	(8, 0)	YC, YTC, and TAF arrays
5	DMAX	(8, 0)	Parts of YC, YTC, and TAF arrays; D_i calculations at point Y_i, X_i
	ABØXC	(8, 0)	Parts of YTC and TT arrays; area calculations of station Y_i
	TBWDC	(8, 0)	Headings for DMAX output
6	PRTG (GEØMW)	(8, 0)	Geometry summary data
7	VSGEØM	(8, 0)	TVS array
	PRTG	(8, 0)	TXY array, if IP(6) = 0.0
	GEØMW	(8, 0)	TGJ array

TABLE 7. IP ARRAY, PRINT CONTROL DATA (CONT)

Array Location	Printing Subroutine	Overlay	Description
8	CTØT1	(14, 0)	YC array; station Y,X for chord calculations
	GCNTL	(14, 0)	Heading for CTØT1 output
	LEWT	(14, 0)	Heading for CTØT1 output
	TEWT	(14, 0)	Heading for CTØT1 output
	TEDEV	(14, 0)	Heading for CTØT1 output
	TEWTI	(14, 0)	Heading for CTØT1 output
9	GCNTL	(14, 0)	TG and TGA arrays
10	LETEI	(14, 0)	TCS, CLEI, and TWG arrays for leading edge; TCS CTEI, and TWG arrays for trailing edge
11	LEWT	(14, 0)	TGR, TST, CCI, CCL, and CCW arrays
	TEWT	(14, 0)	CCW, CCT, and TE arrays
	TEWTI	(14, 0)	TGR, TST, and CCI arrays
12	WLETE	(14, 0)	Heading and trailing edge weight and distribution data and 1-g loads summary
13	MISCNT	(15, 0)	CCI, TST, and TGR arrays
	PRTM (MISCIT)	(15, 0)	CCI, TST, TGR, and TCS arrays
14	MISCNT	(15, 0)	CMII and TVMT arrays
	PRTM (MISCIT)	(15, 0)	TCS and CCI arrays
15	CTØT2	(15, 0)	YC array, station Y,X for chord calculations
	MISCNT	(15, 0)	Heading for CTØT2 output
	MISCIT	(15, 0)	Heading for CTØT2 output
	CDL	(15, 0)	Heading for CTØT2 output
	FDIS	(15, 0)	Heading for CTØT2 output
16	CDL	(15, 0)	TGR and TCS arrays
	TBFWI1	(15, 0)	CCI and TCS arrays
17	FDIS	(15, 0)	CCI, TST, TCS, TWG, and TVMT arrays
18	FDIS	(15, 0)	Fuel distribution summary
19	MTLPW (MTLCW)	(16, 0)	Material properties data, metal design
	TEMPC	(18, 0)	Material properties data, adv comp design
20	ALØAD	(16, 0)	Limit airload and load correction factor summary for metal design
	ACLØAD	(18, 0)	Limit airload and design data summary and ACL array, adv comp design
21	ABDW	(16, 0)	Initial deadweight distribution data
22	GJCAL	(16, 0)	Flutter requirement analysis, summary of results and TVF and TGJ arrays

TABLE 7. IP ARRAY, PRINT CONTROL DATA (CONT)

Array Location	Printing Subroutine	Overlay	Description
	GJTT	(16, 0)	T-tail flutter requirement analysis data
23	WDDATA	(16, 0)	Core status of T and CD arrays at end of overlay (16,0) calculations
24	VLØAD1	(16, 0)	Initial design loads summary for DGWØ and flutter requirement data
	DEADW	(9, 0)	Deadweight summary and adjustment results for NØDW >1, DGW_i
	DWYBA	(9, 0)	Deadweight and Y-bar adjustment data for NØDW >1, DGW_i
	VLØAD	(9, 0)	Design loads and required GJ for NØDW >1, DGW_i
	DEADW	(18, 0)	Deadweight summary and adjustment results for NØDW >1, DGW_i
	DWYBA	(18, 0)	Deadweight and Y-bar adjustment data for NØDW >1, DGW_i
	AVLØAD	(18, 0)	Design loads, required GJ, loads at each condition, DGW_i
25	DEADW	(9, 0)	Deadweight summary and adjustment results for NØDW=1, DGW_i
	DWYBA	(9, 0)	Deadweight and Y-bar adjustment data for NØDW=1, DGW_i
	VLØAD	(9, 0)	Design loads and required GJ for NØDW=1, DGW_i
	DEADW	(18, 0)	Deadweight summary and adjustment results for NØDW=1, DGW_i
	DWYBA	(18, 0)	Deadweight and Y-bar adjustment data for NØDW=1, DGW_i
	AVLØAD	(18, 0)	Design loads, required GJ, loads at each condition for NØDW=1, DGW_i
26	PIVØT	(9, 0)	Pivot design summary data and dump of T(881=1200)
	DLPVT	(9, 0)	Dump of TW array, torque-box weight per inch detail data
	PIVØT	(18, 0)	Same as preceding
	DLPVT	(18, 0)	Same as preceding
27	PRTA(TBØPT)	(9, 0)	Design synthesis and weight distribution summary for NØDW >1, DGW2
	ACPRTA (ATBØPT)	(18, 0)	Design synthesis and weight distribution summary for NØDW >1, DGW2

TABLE 7. IP ARRAY, PRINT CONTROL DATA (CONCL)

Array Location	Printing Subroutine	Overlay	Description
35	CTØT	(17, 0)	YC array, station Y,X for chord calculations
	WVFDD	(17, 0)	Heading for CTØT output
	WFLDD	(17, 0)	Heading for CTØT output
36	WØDATA	(17, 0)	Inertia summary, total structure and contents
37	PRTD	(17, 0)	Detail weight summaries and specified weight coefficients
38	WØDATA	(17, 0)	WCG, CTBW, CTBI, CLEI, CTEI, CMII CFL1I, CFL2I, CCDLI, CIØY, and CCI arrays; mass distribution summary data arays
The following locations are not used by the wing and empennage module. These locations identify wing and empennage related design data printed by other SWEEP routines.			
40*	ØLAY00	(0, 0)	Case title and executed module title
41*	WHVMAT	(3, 0)	Stress versus temperature tables
	WHVOO	(3, 0)	Compressible dynamic pressures
	SVFTAB	(3, 0)	Flutter parameter versus mach number
42*	SPDALT	(2, 0)	Speed profile tables
43*	DSGNPR	(2, 0)	Speed profile design factors
47*	DATAIN	(2, 0)	DC array
	DMAXLD	(2, 0)	Estimated shears and moments
	DDCNTL	(2, 0)	WD array
51*	SPABM	(4, 0)	Calculated shears and moments
53*	WHVNET	(4, 0)	Design loads and load correction factors
54*	BLCNTL	(4, 0)	Temperature and stress for 23 load conditions, design temperature, and load conditions and maximum estimated net bending moments for fatigue analysis

TABLE 8. D ARRAY, INPUT VARIABLE DATA

General information for array D:

Blank common reference location = 2061.

Array size = 2060 cells

Default values are from the SWEEP permanent data bank data sets for wing, horizontal tail, and vertical tail analysis, mass storage file records 23, 26, and 27, respectively. The D array is initialized with these values before the WING, HORIZONTAL, and VERTICAL input data decks are processed for the initial case in a problem setup or for subsequent cases where column 80 of case control card 2 contains a code value of 1. Default value changes can be made either with input data or by revising the permanent data decks.

Locations identified with an asterisk (*) are the variables which may be inputed either through the GENERAL input data decks or from data calculated by the data management module and the flutter and temperature module.

Refer to tables 11 and 12 for assigned variable names and sizes and for location references by overlays and subroutines.

Array Loc	Default Value	Description
1	1.0	CONSTANT = 1.0
2	2.0	CONSTANT = 2.0
3	3.0	CONSTANT = 3.0
4	4.0	CONSTANT = 4.0
5	5.0	CONSTANT = 5.0
6	6.0	CONSTANT = 6.0
7	7.0	CONSTANT = 7.0
8	8.0	CONSTANT = 8.0
9	9.0	CONSTANT = 9.0
10	10.0	CONSTANT = 10.0
11	11.0	CONSTANT = 11.0
12	12.0	CONSTANT = 12.0
13	20.0	CONSTANT = 20.0
14	1000.0	CONSTANT = 1000.0
15	3.1415927	CONSTANT = PI
16	0.01745329	CONSTANT = PI/180
17	144.0	CONSTANT = 144.0
18	24.0	CONSTANT = 24.0
19	0.50	CONSTANT = 1/2

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

Array Loc	Default Value	Description
20	1.5	CONSTANT = 1.5
21	0.33333333	CONSTANT = 1/3
22	0.95	CONSTANT = 0.95
23	1.5	ATT MISC FACTOR, SUBR STBAR, STWEB
24	1.050	ATT MISC FACTOR, SUBR STRIB, NAME = DKMIR
25	0.75	CONSTANT, SUBR STRIB
26	0.3555	OPTIMUM RATIO OF STRINGER FLANGE TO WEB
27	0.125	COVER MISC CONSTANT
28	0.4292	COVER MISC CONSTANT
29	0.75	RIVET SPACING
30	0.001	SEARCH CONSTANT, SUBR STBAR
31	1.01	SEARCH CONSTANT, SUBR TSCH
32	0.06	SEARCH CONSTANT, SUBR TSCH
33	10.0	SEARCH CONSTANT, SUBR TSCH
34	0.01	SEARCH CONSTANT, SUBR TSCH
35	0.045	SEARCH CONSTANT, SUBR TSCH
36	0.95	SEARCH CONSTANT, SUBR BOT
37	0.995	SEARCH CONSTANT, SUBR SFSCH
38	0.9	SEARCH CONSTANT, SUBR SFSCH
39	0.1	SEARCH CONSTANT, SUBR SFSCH
40	1.5	ROOT RIB CAP CONSTANT
41	0.5	REDUCED MODULUS(ER) CONSTANT FOR FLAT PLATES
42	0.5	REDUCED MODULUS(ER) CONSTANT FOR FLAT PLATES
43	0.25	REDUCED MODULUS(ER) CONSTANT FOR FLAT PLATES
44	0.75	REDUCED MODULUS(ER) CONSTANT FOR FLAT PLATES
45	0.83	SPAR WEB GEN INSTAB RED MOD (ERG) CONSTANT
46	0.17	SPAR WEB GEN INSTAB RED MOD (ERG) CONSTANT
47	0.0	NOT USED
48	0.0	NOT USED
49	0.0	NOT USED
50	0.25	CONSTANT (1/4)
51	0.66667	CONSTANT (2/3)
52	0.02	CONSTANT (0.02)
53	0.0	NOT USED
54	0.78539795	CONSTANT, SUBR BHDJT, STWEB
55	0.0	NOT USED

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

56	1.0	CONSTANT, SUBR EFDJT
57	0.2	CONSTANT, SUBR BHDJT
58	0.25	CONSTANT, SUBR EFDJT, DSPLC(1)
59	0.75	CONSTANT, SUBR BFDJT, DSPLC(2)
60	1.5	CONSTANT, SUBR BHDJT, DSPLC(3)
61	0.150	CONSTANT, SUBR BHDJT, DSPLC(4)
62	1.33333	CONSTANT, SUBR BHDJT, DSPLC(5)
63	1.25	CONSTANT, SUBR EFDJT, DSPLC(6)
64	0.0001	SEARCH CONSTANT, SUBR DET, TSCH, SFSCH, STRIB
65	30.0	CONSTANT, MIN STRESS, SUBR, CNSTC, CNSTR
66	25.0	CONSTANT, MIN STRESS, SUBR CNSTC
67	0.50	CONSTANT, MIN RATIO, TSKIN/TBAR, SUBR CNSTC
68	0.70	CONSTANT, MAX RATIO, TSKIN/TBAR, SUBR CNSTC
69	1.0750	ATT. MISC FACTOR, SUBR RTRIB
70	0.838	EFFICIENCY FACTOR, INTEGRAL I-STR
71	1.00	EFFICIENCY FACTOR, INTEGRAL Z-STR
72	0.911	EFFICIENCY FACTOR, RIVETED Z-STR
73	0.05	WING MISC. WT. FACTOR
74	0.50	LOWER COVER COMP. NX FACTOR(CNNX1), SUBR CNSTR
75	0.0	NOT USED
76	0.0	NOT USED
77	0.0	NOT USED
78	0.0	NOT USED
79	0.5	FULL VEL. CALC FACTOR(DLFLD), SUBR FDIS
80	0.0	TAKE-OFF GROSS WEIGHT 1 =TOGW(1) POUNDS
* 81	0.0	TAKE-OFF GROSS WEIGHT 2 =TOGW(2) POUNDS
		-- IF D(81)&D(86)=0.0, DATA TRANSFERRED --
82	0.0	TAKE-OFF GROSS WEIGHT 3 =TOGW(3) POUNDS
83	0.0	CURRENT CASE NUMBER. LOAD DESIRED CASE NUMBER. IF ZERO IN FIRST CASE, 1 IS

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                          ASSUMED.  FOR ALL FOLLOWING CASES IF=0,
                          1 IS ADDED TO LAST CASE NO.  IF NOT 0,
                          CASE NO IS NOT CHANGED

   84      0.0          NOT USED
 * 85      0.0          POSITIVE VERTICAL LOAD FACTOR-LIMIT =DPNZ
                      -- IF D(85)&D(88)=0.0, DATA TRANSFERRED --

 * 86      0.0          NEGATIVE VERTICAL LOAD FACTOR-LIMIT =DNNZ
                      -- IF D(86)&D(88)=0.0, DATA TRANSFERRED --

 * 87      0.0          MAX DYNAMIC PRESSURE, Q, AT V(L) = QVL   LB/SQ FT
                      -- IF D(87)&D(88)=0.0, DATA TRANSFERRED --

 * 88      0.0          BASIC TAKE-OFF GROSS WEIGHT = TOGWO          POUNDS
                      -- CONTROL LOC. FOR DATA BLOCK (81,85,86, --
                         87,89,91,93,94,96,98,100 & 1280)
                            OPTIONS: >0.0 SKIP TRANS. OF DATA
                                          BLK. AND INPUT TOGW FOR
                                          D(88).                     POUNDS
                                     =0.0 TEST EACH LOC. OF DATA
                                          BLOCK FOR TRANSFER. D(88)
                                          TRANSFERRED FROM G.D.

 * 89      0.0          TOTAL FUEL FOR BASIC TAKE-OFF GW = TOFL(1) LB/AV
                          USED FOR CALC. BASIC FLIGHT DESIGN GW,
                          DGWO, FOUND IN D(105).
                          IF POUNDS, SET D(93) = 1.0
                          IF GALLONS, SET D(93) = LB/GAL
                      -- IF D(88)&D(89)=0.0, DATA TRANSFERRED --

   90      0.0          FUEL IN TOGW(1) = TOFL(2).                   LB/AV
                          SIMILAR TO D(89)
 * 91      0.0          FUEL IN TOGW(2) = TOFL(3)                    LB/AV
                          SIMILAR TO D(89)
                      -- IF D(88)&D(91)=0.0, DATA TRANSFERRED --
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
  92    0.0    FUEL IN TOGW(3) = TOFL(4)                          LB/AV
                  SIMILAR TO D(89)

* 93    0.0    FUEL DENSITY = DFUEL                              LB/UNIT
                  TO BE USED WITH D(89-92) TO CALCULATE
                  FUEL LOAD FOR TOGWD, TOGW(1,2,3)
              -- IF D(88)&D(93)=0.0, DATA TRANSFERRED --

* 94    0.0    CONSUMED FUEL OUT TO DESIGN GW = DLFL(1)
                  FOR TOGWD, TO COMPUTE DGWD
                  IF LESS THAN 1, FRACTION OF FUEL
                  INDICATED IN D(89).
                  IF GREATER THAN 1, POUNDS OR GALLONS
              -- IF D(88)&D(94)=0.0, DATA TRANSFERRED --

  95    0.0    CONSUMED FUEL FOR TOGW(1) = DLFL(2)
                  SIMILAR TO D(94)
* 96    0.0    CONSUMED FUEL FOR TOGW(2) = DLFL(3)
                  SIMILAR TO D(94)
              -- IF D(88)&D(96)=0.0, DATA TRANSFERRED --

  97    0.0    CONSUMED FUEL FOR TOGW(3) = DLFL(4)
                  SIMILAR TO D(94)

* 98    0.0    USEFUL LOAD DELTA WT. REMOVED FROM
                TOGW(0),D(88), TO OBTAIN DGW(0)                   LBS/AV
              -- IF D(88)&D(94)=0.0, DATA TRANSFERRED --

  99    0.0    USEFUL LOAD DELTA WT. REMOVED FROM
                TOGW(1), D(80), TO OBTAIN DGW(1)                  LBS/AV

* 100   0.0    USEFUL LOAD DELTA WT. REMOVED FROM
                TOGW(2), D(81), TO OBTAIN DGW(2)                  LBS/AV
              -- IF D(88)&D(100)=0.0, DATA TRANSFERED --

  101   0.0    USEFUL LOAD DELTA WT. REMOVED FROM
                TOGW(3), D(82), TO OBTAIN DGW(3)                  LBS/AV
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		NOTE: LOC D(102) THRU D(105) ARE COMPUTED BY SURF CASE. NO INPUT REQD.
106-109		NOT USED
110	1.0	ID DEAD WT. DISTRIBUTION, INERTIA LOADS CALC OPTIONS: 0.0 NO DEAD WT. DIST. THIS CONDITION MAY BE DESIRED WHEN NET LOADS ARE INPUTED. 1.0 DO DEAD WT. DIST.
111	0.0	NOT USED
112	0.0	NOT USED
113	0.725	CONSTANT DATA-DWT ADJUSTMENT FOR NEXT ITERATION OF WING BOX.
114	0.667	CONSTANT DATA-Y-BAR ADJUSTMENT FOR NEXT ITERATION OF WING BOX.
115	1.0	CONSTANT DATA-ADJUSTMENT TO PANEL CENTROID FOR CHANGE IN NX - STRINGERS ONLY-
116	0.6	CONSTANT DATA-SAME AS D(115) EXCEPT FOR PLATES ONLY-
117	0.985	CONSTANT DATA-CENTROID OF PANEL AS FRACTION OF TOTAL DEPTH.
118-121	0.0	NOT USED
122	1.5	LOAD SAFETY FACTOR-TO CONVERT FROM LIM TO ULT
123		NOT USED
124	0.920	CONSTANT DATA-PIVOT
125	0.15	FS LOC AS FRACTION OF WING CHORD AT BP

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                    INDICATED IN LOC. D(128)-YOU HAVE OPTION
                    TO CHANGE.
126      0.65      RS LOC. AS FRACTION OF WING CHORD AT BP.
                    INDICATED IN LOC. D(128)-YOU HAVE OPTION
                    TO CHANGE.
127      0.40      EA LOC. AS FRACTION OF WING CHORD AT BP
                    INDICATED IN LOC. D(128)-YOU HAVE OPTION
                    TO CHANGE.

128      0.0       SPANWISE LOC. FOR INBD BOX DATA D(125)-D(127)
                      OPTIONS: 0.X FRACTION OF SEMISPAN
                               XX.X BUTTOCK PLANE          INCHES
129      1.0       SPANWISE LOC. FOR OUTBD BOX DATA D(135)-D(137)
                      OPTIONS: 0.X FRACTION OF SEMISPAN
                               XX.X BUTTOCK PLANE          INCHES

130      0.0       NOT USED
131      0.0       NOT USED
132      0.0       NOT USED
133      0.0       NOT USED
134      0.0       NOT USED

135      0.15      FS LOC. AT BP IN D(129)-SEE D(125) FOR
                    OPTIONS.
136      0.65      RS LOC. AT BP IN D(129)-SEE D(126) FOR
                    OPTIONS.
137      0.40      EA LOC. AT BP IN D(129)-SEE D(127) FOR
                    OPTIONS.

* 138    0.25      FRACTION OF CHORD FOR ELEMENT ANGLE IN D(242).
                 -- IF D(138),D(242)&D(240)=0.0, DATA TRANS. --

                   NOTE: DATA LOC D(139) = OUTBOARD CONTROL STATION
                         USED TO LOCATE TORQUE-BOX ON THE EXPOSED
                         PANEL, IF STRUCTURAL STATIONS ARE NOT
                         INPUT.  BUTTOCK PLANE STATION CALC FROM
                         THIS ITEM = BP OF STRUCT STA 11.  PROGRAM
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		WILL TREAT STRUCTURES OUTBD OF THIS STA-TION TO THE TIP STA AS THE SURFACE TIP STRUCTURE.	
139	0.975	SPANWISE CONTROL STATION FOR Y(11). OPTIONS: 0.0, 1.0 USE B/2 STATION 0.XX FRACTION OF B/2 XX.X BUTTOCK PLANE STATION	IN.
140		NOT USED	
141	0.0	SPANWISE LOC. FOR T/C VALUE IN D(243). OPTIONS: 0.X FRACTION OF SEMISPAN XX.X BUTTOCK PLANE	INCHES
142	1.0	SPANWISE LOC. FOR T/C(TP)/T/C(RT) VALUE IN D(245). OPTIONS: SAME AS D(141)	
		NOTE: D(143), D(145) THRU D(152) USED FOR AIRFOIL DESCRIPTION. LOCAL DEPTH AT X/C PT ON AIRFOIL, EVALUATED: A. F(POLYNOMIAL FIT). EQUATION CONSTANTS STORED IN DATA BANK, DAF ARRAY, LOC 1-99. B. F(ST. LINE INTERPOLATION OF DEPTH VS X/C TABLES). DATA SET STORED IN DATA BANK, DAF ARRAY, LOC 101-500.	
143	2.0	IC TYPE OF AIRFOIL AND DATA SET EVALUATION. OPTIONS: 1.0 - 8.0 AIRFOIL TYPE BASED ON CURVE FIT DATA-- 1.0 = NACA 6300 AIRFOIL 2.0 = NACA 6400 AIRFOIL 3.0 = NACA 6500 AIRFOIL 4.0 = NACA 6600 AIRFOIL 5.0 = WEDGE AIRFOIL 6.0 = ARC AIRFOIL 7.0, 8.0 NOT USED NOTE: THIS OPTION WILL RESULT IN	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		CONSTANT SHAPE AIRFOIL FROM ROOT TO TIP. DATA IN D(145) THRU D(152) NOT REQUIRED. 9.0 = AIRFOIL TYPE BASED ON ST LINE FIT DATA. DATA REQUIRED IN D(145) THRU D(152) TO SPECIFY SHAPE DATA SET TO BE USED AND TO LOCATE REF. LOC. ON SURFACE SPAN. ONE TO FOUR DIFF. SHAPES CAN BE SPECIFIED, WITH INTERMEDIATE LOCAL DEPTHS BASED ON DOUBLE INTERPOLATION OF NORMALIZED DEPTH DATA.
* 144	0.0350	SURFACE WT (LB/SIDE) FOR INITIAL STRUCT WT DIST OPTIONS: 0.XXX FRACTION OF DGWO XXX.X TOTAL WT/SIDE 0.0 EST. TRANSFERED FROM GD
145	0.0	SPANWISE LOC. FOR AIRFOIL NO.1 OPTIONS: 0.0 NOT USED 0.X FRACTION OF SEMISPAN XX.X BUTTOCK PLANE INCHES
146	0.0	SPANWISE LOC FOR AIRFOIL NO.2-SAME OPTIONS AS D(145)
147	0.0	SPANWISE LOC. FOR AIRFOIL NO.3-SAME OPTIONS AS D(145)
148	0.0	SPANWISE LOC. FOR AIRFOIL NO.4-SAME OPTIONS AS D(145)
149	0.0	ID TYPE OF AIRFOIL TO BE LOCATED AT STA. SPECIFIED IN D(145). USE NOS 1.0 TO 5.0 TO DENOTE

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                    THE TABULATED DEPTH DATA SET TO BE USED FROM
                    DATA BANK ARRAY DAF, LOC(150-399).
                       NOTE: AIRFOIL DEPTH ORDINATES STORED IN SETS
                             OF 50 ITEMS/BLOCK STARTING AT DAF(150)
                             DAF(100-149) CONTAINS THE REF X/C DATA
                                 **X/C BLOCK**
                               DAF(100) = NO. OF X/C PTS.
                               DAF(101-148) = X/C VALUES.
                               DAF(149) NOT USED
                                 **DEPTH BLOCK 1**
                               DAF(150) = AIRFOIL ID -- REF ONLY
                               DAF(151-198) = AIRFOIL DEPTHS AT X/C
                                       POINTS IN DAF(101-148).
                               DAF(199) = MAX VALUE OF AIRFOIL
                                       DEPTHS IN SET.  VALUE USED
                                       FOR NORMALIZING.
                                 **OTHER BLOCKS SAME SETUP AS 1**

                             FOR 2 OR MORE AIRFOILS SPECIFIED:
                               CONSTANT AIRFOILS ARE ASSUMED INBD
                               OF THE FIRST PT. AND OUTBD OF THE
                               OUTER MOST PT.

                             CURRENT SETUP FOR DAF(100-399):
                               NO. OF X/C PTS = 0.0
                               DEPTH BLOCK 1 =  NO DATA
                                           2 =  NO DATA
                                           3 =  NO DATA
                                           4 =  NO DATA
                                           5 =  NO DATA

                             ACTUAL CHORD LENGTHS ARE USED FOR CALC
                               OF X/C AND LOCAL AIRFO-L DEPTHS--FOR
                               BLENDED AND CRANKED WING PLANFORMS,
                               THE DELTA CHORD LENGTH DATA ARE USED
150      0.0        ID TYPE OF AIRFOIL TO BE LOCATED AT STA. SPECI-
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		FIED IN D(146). SAME AS D(149).
151	0.0	ID TYPE OF AIRFOIL TO BE LOCATED AT STA. SPECIFIED IN D(147). SAME AS D(149).
152	0.0	ID TYPE OF AIRFOIL TO BE LOCATED AT STA. SPECIFIED IN D(148). SAME AS D(149).
153	20.0	NO OF EQUALLY SPACED CHORDWISE CUTS FOR NUMERICAL INTEG. OF T-BOX X-SEC AREA AT EACH STA
154		NOT USED
155	0.0	NOT USED
156	1.5	CONSTANT DATA-PIVOT E/D=EDGE DISTANCE/DIAMETER
157	5.5	-PIVOT D/T=DIAMETER/THICKNESS
158		NOT USED

* D(159)-D(174) IS USED FOR SEQUENCING THE REMOVAL OF FUEL AND USEFUL LOAD FROM FUEL CELLS 1&2 AND STORE STATIONS 1&2 FOR CALC OF INERTIA LOADS AT THE DESIGN GROSS WT. CONDITION. MAX AMOUNT REMOVED WILL BE DEPENDANT ON A). WING FUEL AND STORE LOADING DATA B). DELTA FUEL AND USEFUL LOAD DATA IN D(94) THRU D(101).

OPTIONAL INPUTS FOR D(159)-D(174)-

- 0.0=NO FUEL WT. OR STORES REMOVED FROM INDICATED FUEL CELL OR STORE STATION.
- 1.0=REMOVE WT. FROM INDICATED FUEL CELL OR STORE STATION FIRST.
- 2.0=REMOVE WT. FROM INDICATED FUEL CELL OR STORE STATION SECOND.

NOTE: AFTER REMOVING FUEL AND USEFUL LOAD DELTA WTS. FROM THE FUEL CELLS AND STORE STATIONS THE REMAINDER(IF ANY) IS REMOVED FROM THE FUSELAGE FUEL &

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		USEFUL LOAD WTS. TO ARRIVE AT THE DGW(S) DEFINED IN D(80) THRU D(101).	
159	1.0	ID FUEL CELL NO.1-TOGW(0) D(88)	
160	1.0	-TOGW(1) D(80)	
161	1.0	-TOGW(2) D(81)	
162	1.0	-TOGW(3) D(82)	
163	2.0	ID FUEL CELL NO.2-TOGW(0)-D(88)	
164	2.0	-TOGW(1)-D(80)	
165	2.0	-TOGW(2)-D(81)	
166	2.0	-TOGW(3)-D(82)	
167	0.0	ID STORE STATION NO.1-TOGW(0)-D(88)	
168	0.0	-TOGW(1)-D(80)	
169	0.0	-TOGW(2)-D(81)	
170	0.0	-TOGW(3)-D(82)	
171	0.0	ID STORE STATION NO.2-TOGW(0)-D(88)	
172	0.0	-TOGW(1)-D(80)	
173	0.0	-TOGW(2)-D(81)	
174	0.0	-TOGW(3)-D(82)	
		** D(175) THRU D(178) DEFINE THE WING ** REFERENCE POINT FOR THE LOCATION OF THE WING WITH RESPECT TO THE BODY	
* 175	0.0	SPANWISE REFERENCE FOR WING REFERENCE POINT -BP(Y) -- IF DM RUN THEN D(175) ALWAYS SET =0.0 --	INCHES
* 176	1000.0	FUSELAGE REFERENCE FOR INTERSECTION OF WING REFERENCE POINT & FUSELAGE STATION --IF DM RUN THEN D(176) ALWAYS SET = WING APEX --	INCHES
* 177	0.0	WING REFERENCE CHORD FOR BP(Y) IN D(175) -- IF DM RUN THEN D(177) ALWAYS SET =0.0 --	INCHES

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

* 178	0.0	X/C OR DISTANCE FROM LE FOR PT. IN D(176) -- IF DM RUN THEN D(178) ALWAYS SET =0.0 --
179-185		NOT USED
186	1.0	ID PIVOT DEPTH OPTIONS: 0.0 DEPTH WITHIN W.M.L. 1.0 OUTER LUG WITH IN W.M.L. >1.0 DEPTH INCHES
187.188		NOT USED
189	0.85	REDUCTION FACTOR FOR TENSION ULT. STRESS ALLOWABLE FOR PIVOT MAT'L. YOU HAVE OPTION TO CHANGE.
190	1.0	RATIO - FSU(PIN)/FSU(PIVOT)
191	1.0	RATIO - DENSITY(PIN)/DENSITY(PIVOT)
192	9.838356	CKA-CONSTANT FOR CURVE FIT,BUCKING CONSTANT VS. PANEL ASPECT RATIO.
193	0.72665	CKB-CONSTANT FOR CURVE FIT-SEE 192
194	4.40	CKC-CONSTANT FOR CURVE FIT-SEE 192
195	0.0	PIVOT BEARING STRESS-DESIRED LEVEL FOR THE DESIGN LBS/SQ IN
* 196	0.0	PIVOT MAT'L NUMBER-SEE MAT'L LIBRARY IF ZERO PROGRAM USES WING MATERIAL
*197	0.0	PIVOT MAT'L TEMPERATURE. DEGREES FAHRENHEIT
198	0.0	PIN OUTER DIAMETER. OPTIONS: 0.0 USE STRESS IN D(195) X.X BEARING STRESS CALC. FROM INPUT DATA.
* 199	0.0	NUMBER OF SWEEP POSITIONS OF THE PIVOT TO BE CONSIDERED IN ADDITION TO THE INITIAL

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                            POSITION.
                         -- IF =0.0, TRANSFER DATA --

* 200      0.C            SPANWISE LOC. FOR PIVOT
                              OPTIONS:  0.X FRACTION OF SEMISPAN
                                       XX.X BUTTOCK PLANE              INCHES
                         -- IF =0.0, TRANSFER DATA --

* 201      0.0            CHORDWISE LOC. FOR PIVOT
                              OPTIONS: 0.X FRACTION OF LOCAL CHORD
                                           FROM LE.
                                      XX.X DIST.FROM LE                INCHES
                         -- IF =0.0, TRANSFER DATA --

* 202      0.0            SWEEP ANGLE OF LE-FWD POSITION              DEGREES
                         -- IF =0.0, TRANSFER DATA --
* 203      0.0            SWEEP ANGLE OF LE-AFT POSITION              DEGREES
                         -- IF =0.0, TRANSFER DATA --
* 204      0.0            ID T-TAIL(FOR H.TAIL INPUT ONLY)
                              OPTIONS: 0.0 DATA TRANSFERRED FROM GD
                                       1.0 T-TAIL(H.TAIL INPUT ONLY)

* 205      0.0            ID DESIGN AIRLOADS DATA TRANSFER.
                              OPTIONS: 0.0 = DATA FROM VARIABLE DATA SET
                                             FOR SURFACE.
                                       1.0 = DATA FROM LOADS MODULE.

                          NOTE: DATA LOC D(206) THRU D(219) DESCRIBES FUEL
                                CELL AND CONTENTS.  TWO FUEL CELLS CAN BE
                                LOCATED WITHIN THE SURFACE TORQUE-BOX.

* 206      0.0            SPANWISE LOC. INBD(Y)-CELL NO.1
                              OPTIONS: 0.X FRACTION OF SEMISPAN
                                      XX.X BUTTOCK PLANE               INCHES
                         -- IF D(206)&D(208)=0.0, TRANSFER DATA --

* 207      0.0            SPANWISE LOC. OUTBD(Y)-CELL NO.1
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		SAME OPTIONS AS INBD(Y)-SEE D(206)	
		-- IF D(207)&D(208)=0.0, TRANSFER DATA --	
* 208	0.026	FUEL DENSITY AND FUEL CELL #1 DATA BLOCK (206-212) ID-	
		OPTIONS: 0.0 D(208) DATA TRANSFERRED FROM GD AND DATA BLOCK LOCATIONS TESTED FOR TRANSFER	
		0.X INPUT DENSITY AND NO DATA BLK TEST.	
* 209	0.0	WT. OF FUEL IN CELL NO.1 FOR DGW CONDITION	
		OPTIONS: <1.0 FRACTION OF CELL CAPACITY FOR DGN CONDITION	
		>1.0 WEIGHT REQUIRED	LBS/SIDE
		-- IF D(208)&D(209)=0.0, TRANSFER DATA --	
* 210	0.0	CAPACITY OF CELL NO.1	
		OPTIONS: 0.0 PROG. USES CAPACITY CALC. FROM INPUT DATA.	
		XX.X WEIGHT/SIDE	LBS/SIDE
		-- IF D(208)&D(210)=0.0, TRANSFER DATA --	
* 211	0.0223	WT. OF FUEL SYSTEM/SIDE AS % OF CAPACITY FOR CELL NO.1. YOU HAVE OPTION TO CHANGE.	
		-- IF D(208)&D(211)=0.0, TRANSFER DATA --	
212		NOT USED	
		* D(213) THRU D(219) INPUT DATA BLOCK FOR FUEL CELL NUMBER TWO. THE INPUT AND TRANSFER OPTIONS FOR CELL NO.2 ARE EXACTLY THE SAME AS FOR CELL NO.1.	
* 213	0.0	INBD(Y) CELL NO.2-SEE D(206)	INCHES
* 214	0.0	OUTBD(Y) CELL NO.2-SEE D(207)	INCHES
* 215	0.026	FUEL DENSITY-SEE D(208)	LBS/CU IN

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

* 216	0.0	WT. FUEL FOR DGW CELL NO.2-SEE D(209)	LBS/SIDE
* 217	0.0	WT. FUEL CAPACITY CELL NO.2-SEE D(210)	LBS/SIDE
* 218	0.0223	% OF CAPACITY FOR FUEL SYS. WT-SEE D(211)	
219		NOT USED	
		NOTE: DATA LOC D(220) THRU D(231) DESCRIBES EXTERNAL CONC. AIRLOADS TO BE ADDED TO DISTRIBUTED AIRLOADS. THE LOADS MUST BE LIMIT VALUES FOR DGWO AND IN THE REF. SYSTEM SPECIFIED BY THE CONTROL ID OF EACH SET.	
220	0.0	ID CONC. AIRLOAD NO.1	
		OPTIONS: 0.0 NO AIRLOAD	
		1.0 = LOADS IN FUSELAGE REF SYSTEM.	
		2.0 = LOADS IN SURFACE REF SYSTEM.	
221	0.0	SPANWISE LOC. FOR AIRLOAD NO.1	
		OPTIONS: 0.X FRACTION OF SEMISPAN.	
		XX.X BUTTOCK PLANE	INCHES
222	0.0	CHORDWISE LOC. FOR AIRLOAD NO.1	
		OPTIONS: 0.X FRACTION OF LOCAL CHORD FROM LE	
		XX.X DIST. FROM LE	INCHES
223	0.0	VERTICAL SHEAR PER SIDE	LBS/SIDE
224	0.0	B. MOM. OF LOAD AT SPECIFIED COORD.	IN-LB
225	0.0	T. MOM. OF LOAD AT SPECIFIED COORD.	IN-LB
		* D(226)-D(231) ARE THE INPUT LOC. FOR CONC. AIRLOAD NO.2. THESE LOC. REQUIRE THE DATA & OPTIONS AS D(220) THRU D(225).	
226	0.0	ID-CONC. AIRLOAD NO.2-SEE D(220)	
227	0.0	BP(Y)-SEE D(221)	INCHES
228	0.0	X(FUS)-SEE D(222)	INCHES
229	0.0	SHEAR/SIDE-SEE D(223)	LBS/SIDE
230	0.0	B. MOM. OF LOAD AT SPECIFIED COORD.	IN-LB

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
 231     0.0       T. MOM. OF LOAD AT SPECIFIED COORD.          IN-LB

                   NOTE: DATA LOC D(232) THRU D(239), D(255),
                         D(256) AND D(257) ARE USED FOR DESIGN
                         AIRLOADS CALC BY THIS MODULE IF LOADS
                         ARE NOT TRANSFERED FROM THE LOADS MODULE.

 232     0.80      CONSTANT USED AS EXPONENT OF P USED IN
                    ASSUMED LOAD DIST. CALC. FOR UNIT LOAD
                    ON EXP. AREA. R=RATIO OF(EXP.SW/EXP. B)
                    TO (GROSS SW/B)
 233     1.0       FACTOR FOR TAPER RATIO OF ASSUMED AIRLOAD
                    ON EXP. WING. YOU CAN CHANGE.
 234     1.0       FACTOR FOR AIRLOAD SHEAR. YOU CAN CHANGE.
 235     0.0       WING AREA SUBJECT TO AIRLOAD-IF ZERO         SQ FT
                    D(240),D(241)&D(244) WILL BE USED.
 236     0.0       ASPECT RATIO FOR D(235)
 237     0.0       TAPER RATIO FOR D(235)
 238     0.0       SPAN OF WCS-USED IN ASSUMED LOAD CALC.      INCHES
*239     0.0       FRACTION OF CHORD (X/C) TO DEFINE LOAD REF LINE
                    IF DIFF FROM EA.

                   NOTE: DATA LOC D(240) THRU D(249) DESCRIBES THE
                         THEORETICAL PLANFORM GEOMETRY OF THE
                         SURFACE.

* 240    0.0       WING AREA AND BASIC WING GEOMETRY DATA BLOCK
                    (138,240-248) ID-
                      OPTIONS: =0.0 AREA FOR 240 TRANSFERRED
                                    FROM GD AND TEST EACH LOC.
                                    OF DATA BLOCK FOR TRANSFER
                                    OPTION.
                               >0.0 INPUT WING BASIC AREA AND
                                    NO TEST OF DATA BLOCK.
                                    NOTE: USE DOUBLE THE AREA
                                          OF ONE PANEL FOR V.T.
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

* 241	0.0	D(240) ASPECT RATIO. USE DOUBLE THE ASPECT RATIO OF ONE PANEL FOR THE V.TAIL. -- IF D(240)&D(241)=0.0, TRANSFER DATA --	
* 242	0.0	SWEEP OF REF CHORD ELEMENT (X/C OF D(138)) -- IF D(240)&D(242)=0.0, TRANSFER DATA --	DEG
* 243	0.0	THICKNESS RATIO AT SPANWISE LOCATION IN D(141). -- IF D(240)&D(243)=0.0, TRANSFER DATA --	
* 244	0.0	D(240) TAPER RATIO -- IF D(240)&D(244)=0.0, TRANSFER DATA --	
* 245	0.0	RATIO OF THICKNESS RATIOS. T/C AT SPANWISE LOCATION IN D(142) DIVIDED BY T/C IN D(243). -- IF D(240)&D(245)=0.0, TRANSFER DATA --	
* 246	0.0	FUSELAGE SPAN AT SHEAR TIE POINTS. -- IF D(240)&D(246)=0.0, TRANSFER DATA -- NOTE: VALUE IN D(246)/2.0 = REF BP LOC OF INBD STA OF EXPOSED SURFACE USED TO LOCATE STRUCT. STA 1 AND EXPOSED SPAN FOR LOADS AND FLUTTER ANALYSIS IF APPROPRIATE OPTIONAL INPUTS ARE NOT INPUT: --D(864-875) FOR INPUT STATIONS --D(238) FOR LOADS EXPOSED SPAN --D(343) FOR FLUTTER EXPOSED SPAN	INCHES
* 247	0.0	WING DIHEDRAL ANGLE OPTIONS: +XX.X=ANGLE ABOVE WRP. -XX.X=ANGLE BELOW WRP. -- IF D(240)&D(247)=0.0, TRANSFER DATA --	 DEGREES DEGREES
* 248	0.0	DISTANCE OF WING REFERENCE FROM FUS. REFERENCE PLANE AT CENTERLINE OF VEHICLE.	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                          OPTIONS: +XX.X=DISTANCE WRP IS     INCHES
                                        ABOVE FRP.
                                   -XX.X=DISTANCE WRP IS     INCHES
                                        RELOW FRP.
                     -- IF D(240)&D(248)=0.0, TRANSFER DATA --

  249                NOT USED
  250     1.0        TOTAL WING WEIGHT COEFFICIENT

  251     0.0        INDICATOR VF CALCULATIONS.
                          OPTIONS: 0.0 NO ANALYSIS
                                   1.0 CALCULATE GJ
                                   2.0 INPUT GJ OR J IN D(346)
                                       THRU D(356)
                                  -1.0 CALC GJ BUT WITH CONSTANT
                                       REQD GJ FOR STRUCT STATIONS
                                       INBD OF STA INDICATED BY
                                       D(313) AND OUTBD OF STA OF
                                       D(315). THE GJ VALUES =
                                       CALC VALUES AT THE CONTROL
                                       STATIONS.
  252     1.15       FACTOR FOR FLUTTER OVERSPEED.
                          OPTIONS: 1.0 WHEN Q IS CALC. BY
                                       FLUTTER PROGRAM OR IF
                                       D(253) INCLUDES FLUTTER
                                       MARGIN.
                                   1.15 THEN D(1441)=1.0
                                   1.20 THEN D(1441)=1.1
* 253     0.0        MAXIMUM CRITICAL COMPRESSIBLE DYNAMIC
                      PRESSURE FOR SURFACE FLUTTER.
                          OPTIONS: XXX.X Q             LBS/SQ. FOOT
                                     0.0 USE Q FROM
                                         FLUTTER PROGRAM
* 254     0.0       MODULUS OF RIGIDITY, G, OF T-BOX MATL AT FLUTTER
                     DESIGN POINT--USED FOR CALC OF MAX REQD STRUCT
                     J.  VALUE SHOULD BE COMPATIBLE WITH FLUTTER
                     DESIGN TEMP INDICATED IN D(282), IF NOT, THE
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                        INDICATED REQD GJ VALUE WILL BE A SCALED VALUE
                        BUT THE REQD STRUCTURAL J VALUE WILL NOT CHANGE
                            OPTIONS: 0.0 A).  MUST NOT BE ZERO IF G IS
                                              NOT TRANSFERED THRU DATA
                                              MANAGEMENT LOGIC.
                                          B).  MUST BE ZERO IF DATA MANA-
                                              GEMENT VALUE IS REQD.
                                     10.0 OR LESS.  G = MATL G AT ROOM
                                                         TEMP * INPUT
                                                           VALUE.
                                     GREATER THAN 10.0. G = INPUT     PSI

255      0.0            AIRLOAD SHEAR PER SIDE.                    LBS(LIM)
                         OPTIONS IF LOADS DATA TO BE CALC BY MODULE:
                                 0.0 EST EXPOSED SURFACE LOAD = F(NZ,
                                     DGW, GROSS AREA AND SPAN, EXPOSED
                                     AREA AND SPAN)
                                 XXX.X LIMIT LOAD                  LB/SIDE
                         NOTE: LOAD TO BE DISTRIBUTED ON EXPOSED
                                 SPAN BASED ON CP DATA FROM D(256)
                                 AND D(257).
                               D(255,256,257) NOT REQD IF:
                                 D(205) = 1.0 - USE LOAD DATA FROM LOADS
                                                MODULE, OR
                                 D(894) NOT 0.0 - INPUT LOADS AT 11 STA.
256      0.0            SPANWISE LOCATION FOR CENTER OF PRESSURE.
                                         0.XX FRACTION OF EXPOSED
                                              SEMISPAN.
                                        XX.XX DISTANCE FROM EXP.   INCHES
                                              WING ROOT CHORD TO
                                              C.P.
                                         0.0  ASSUMES CONDITIONS.
                                        -0.XX FRACTION OF SEMISPAN
                                       -XX.XX DISTANCE FROM FUS.   INCHES
                                              CENTERLINE TO C.P.
257      0.40           CHORDWISE LOCATION FOR CENTER OF PRESSURE.
                                         0.XX FRACTION OF CHORD AT CP
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                                    0.0  ASSUME CONDITIONS
  258     0.0       ID MATERIAL FOR TORQUE-BOX DESIGN--COVERS, SPARS
                     AND RIBS--METALLIC STRUCTURES.  MATL DATA FROM
                     DATA BANK MATERIAL LIBRARY.
                         NOTE: A MATL NO MUST BE INDICATED WHEN THE
                               ADV. COMP OPTION IS USED.
* 259     0.0        MATERIAL TEMPERATURE-TORQUE BOX         DEGREES F
                   -- IF D(259)=0.0, TRANSFER DATA --

  260-270 0.0       INPUT B. MOM, POSI. LOAD CONDITION, LIMIT    IN/LB
                     FOR DGWO AT THE 11 STRUCTURAL DESIGN
                     STATIONS.
                     DATA REQD IF INPUT LOAD CONTROL ID D(686)
                     IS 1.0 OR 2.0 AND LOADS MODULE DATA TRANSFER
                     ID D(205) IS 0.0.
                         NOTE: BM VALUES MUST BE IN THE SURFACE
                               STRUCTURAL REF SYSTEM.

  271     0.0       ID MASS DISTRIBUTION AND DESIGN DATA GENERATION
                     FOR FLEX LOADS AND FLUTTER OPT PROGRAMS.
                         OPTIONS: 0.0 NO CALC NECESSARY
                                  1.0 DATA CALC FOR BOTH PROGRAMS
                                  2.0 DATA CALC FOR FLEX LOADS ONLY
                                  3.0 DATA CALC FOR FLUTTER OPT ONLY
                         NOTE: THIS ID CONTROLS ANALYSIS ONLY. PUNCH-
                               ED CARD OUTPUT IS CONTROLLED BY DATA
                               LOC D(280).

                    NOTE: DATA LOC D(272) THRU D(279) ARE USED TO
                           CONTROL INTERNAL FUEL AND EXTERNAL STORES
                           AT THE DESIGN LOADING CONDITIONS FOR FLEX
                           LOADS AND FLUTTER OPT ANALYSIS.
  272     0.0        FRACTION OF WT OUT-FLEX LOAD COND-FUEL CELL NO.1
  273     0.0                                        -FUEL CELL NO.2
  274     0.0                                        -STORE STA NO.1
  275     0.0                                        -STORE STA NO.2
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

276	0.0	FRACTION OF WT OUT-OF CONDITION-FUEL CELL NO.1	
277	0.0	-FUEL CELL NO.2	
278	0.0	-STORE STA. NO.1	
279	0.0	-STORE STA. NO.2	
280	0.0	ID DATA CARD PUNCH OF MASS DISTRIBUTION AND DESIGN DATA FOR FLEX LOADS AND FLUTTER OPT PROGRAMS. OPTIONS: 0.0 NO DATA CARDS 1.0 PUNCH DATA CARDS	
		NOTES ON D(281) THRU D(284): DESIGN TEMPERATURES TO BE USED IN STIFFNESS CALC ONLY. D(282) FOR METALLIC AND ADV. COMP, D(281),D(283) AND D(284) FOR ADV. COMP ONLY.	
281	0.0	REF TEMP FOR OUTPUT OF EI AND GJ FOR ST. DESIGN, ADV. COMP ANALYSIS. IF 0.0, THE BASIC DESIGN TEMP IN D(259) WILL BE USED.	DEG
*282	0.0	DESIGN TEMP FOR FLUTTER ANALYSIS, METALLIC AND ADV. COMP ANALYSIS. IF 0.0: A). BASIC DESIGN TEMP IN D(259) WILL BE USED OR B). CALC TEMP AT CRITICAL FLUTTER PT WILL BE TRANSFERED THRU DATA MANAGEMENT LOGIC.	DEG
283	0.0	REF TEMP FOR CALC OF EI AND GJ FOR FLEX LOADS ANALYSIS, ADV. COMP ONLY. IF 0.0, TEMP SPECIFIED FOR ST DESIGN EI AND GJ WILL BE USED. NOT REQD IF FLEX LOADS DATA ARE NOT CALC.	DEG
284	0.0	REF TEMP FOR CALC OF EI AND GJ FOR FLUTTER OPT ANALYSIS, ADV. COMP ONLY. OPTIONS SAME AS FOR D(283).	DEG
285-288	0.0	DO NOT USE. FOR INTERNAL PROGRAM USE ONLY.	
* 289	0.0	INDICATOR FOR TYPE SURFACE OPTIONS: 0.0 WING	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		-1.0 HORIZONTAL TAIL +N.0 VERTICAL TAIL(N=NUMBER OF PANELS). -- D(289) AUTOMATICALLY SET TO WING OR H. -- TAIL ID BY G.D. TRANSFER. IF V.TAIL IS RUN THEN USER MUST INPUT NO. OF PANELS.	
		NOTE: DATA LOC D(290) THRU D(309) FOR MASS AND DESIGN DATA GENERATION OPTION.	
290	0.0	MN AT 20K FEET FOR FIXED OR SWEPT AFT WING. FLEX LOAD DESIGN CONDITION. OPTIONS: 0.0 PROG. CALC. VALUE FOR MN X.X INPUT MN	
291	0.0	MN AT 20K FEET FOR VARIABLE SWEEP WING,FWD POSITION. FLEX LOAD DESIGN CONDITION. SAME OPTIONS AS D(290).	
292	0.0	ELASTIC MODULUS, E, FOR STIFFNESS CALC, FLEX LOADS DESIGN CONDITION. METALLIC DESIGN ONLY.	PSI
293	0.0	SHEAR MODULUS, G, FOR STIFFNESS CALC, FLEX LOAD DESIGN CONDITION. METALLIC DESIGN ONLY.	PSI
294		NOT USED	
295	0.0	DGW FOR VF CONDITION.	LBS
296	0.0	X.CG (FUS. STATION) FOR D(295)	INCHES
297	0.0	IYY PITCH INERTIA FOR D(295)	LB-IN SQ
298	0.0	IXX ROLL INERTIA FOR D(295)	LB-IN SQ
299	0.0	WEIGHT-EXPOSED WING AND CONTENTS PER SIDE.	LBS/SIDE
300	0.0	Y-CG FOR WT. IN D(299)	INCHES
301	0.0	X-CG FOR WT. IN D(299)	INCHES
302	0.0	IYY PITCH INERTIA FOR D(299)	LB-IN SQ

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

303	0.0	IXX ROLL INERTIA FOR D(299)	LB-IN SQ
304	0.0	MN FOR VF CONDITION	
305	0.0	ALTITUDE FOR MN IN D(304)	FEET
306	0.0	DENSITY OF AIR FOR DESIGN POINT IN D(304). IF ZERO THEN PROG. CALC DENSITY FROM D(304) & D(305).	LBS/CU IN
307	0.0	ELASTIC MODULUS, E, FOR STIFFNESS CALC, FLUTTER OPT DESIGN CONDITION. METALLIC DESIGN ONLY.	PSI
308	0.0	SHEAR MODULUS, G, FOR STIFFNESS CALC, FLUTTER OPT DESIGN CONDITION. METALLIC DESIGN ONLY.	PSI
309	1.15	VF SPEED FACTOR- OPTIONS: 1.15 MILITARY 1.20 COMMERCIAL	
*310	0.0	DIHEDRAL OF H.TAIL WHEN RUNNING T-TAIL FOR V.TAIL PORTION ONLY. SEE D(357) THRU D(360). REQD FOR VERT TAIL FLUTTER REQMT CALC IF CONFIG. IS T-TAIL.	DEGREES
311		NOT USED	
312	1.0	FACTOR FOR GJ CALCULATION.	
313	0.90	SPANWISE LOCATION FOR WHICH D(314) APPLIES. OPTIONS: 1-FRACTION OF EXP. 2-BUTTOCK STATION IF D(251)=-1.0 THEN GJ FROM D(313) INBD. HELD CONSTANT.	INCHES
314	1.0	GJ COEFF. FOR STRUCTURE INBD OF STATION D(313)	
315	0.99	SPANWISE LOCATION FOR WHICH D(316) APPLIES. OPTIONS: 1-FRACTION OF EXP. SEMI-SPAN	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

			2-BUTTOCK STATION IF D(251)=-1.0 THEN GJ FROM D(315) OUTBD. HELD CONSTANT.	INCHES
	316	0.001	GJ COEFF. FOR STRUCTURE OUTBD OF STATION D(315)	
	317	0.0	CONSTANT DATA RELATIVE ROTATION AT ROOT STA FOR FLUTTER ANALYSIS--ART.	
	318	1.0	CONSTANT DATA RELATIVE ROTATION AT TIP STA FOR FLUTTER ANALYSIS--ATIP.	
	319	0.0	NOT USED.	
			NOTE: DATA LOC D(320) THRU D(324)--FLUTTER REQMT ANALYSIS DATA FOR WING POSITION OF VARIABLE SWEEP DESIGNS OTHER THAN THAT INDICATED IN D(242). USED ONLY IF D(200) IS INPUT NON-ZERO NC (PIVOT REQD) AND AND D(251) IS 1.0 OR -1.0 (FLUTTER CALC). ALL DATA REQD FOR FIXED SURFACE FLUTTER ANALYSIS MUST BE SETUP.	
*	320	0.0	DELTA SWEEP OF WING PANEL, (+/-), TO POSITION REQD FOR FLUTTER ANALYSIS. IF 0.0, AND DATA IS REQD, THIS DELTA IS DETERMINED FROM DATA MANAGEMENT C/4 CALC DATA.	DEG
*	321	0.0	CRITICAL FLUTTER Q FOR SWEPT POSITION. SAME AS D(253).	LB/SF
*	322	0.0	STRUCTURAL MATL G FOR FLUTTER ANALYSIS AT SWEPT POSITION. SAME AS D(254).	PSI
*	323	0.0	DESIGN TEMP FOR FLUTTER ANALYSIS AT SWEPT POSITION. SAME AS D(282).	DEG F
	324	0.0	FLUTTER OVERSPEED FACTOR, SAME AS D(252).	
	325-334	0.0	NOT USED.	
			NOTE: DATA LOC D(335) THRU D(339)--FLUTTER REQMT ANALYSIS DATA FOR VERT TAIL, T-TAIL CONFIG	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		ONLY. TWO OPTIONS FOR DATA SET: IF D(336) = 0.0, ASSUMES HORIZONTAL TAIL EFFECT COEFF. CTT IN D(339) IS INPUT OR TRANSFERED THRU DATA MANAGEMENT LOGIC. IF D(336) = X.XX, MODULE WILL CALC HORIZONTAL TAIL EFFECT COEFF CTT ALL DATA REQD FOR CONVENTIONAL VERT TAIL FLUTTER ANALYSIS MUST BE SETUP.	
* 335	0.0	DESIGN TEMP FOR T-TAIL VERT TAIL FLUTTER ANALYSIS. IF 0.0, CALC DATA MANAGEMENT FLUTTER TEMP OR BASIC DESIGN TEMP IN D(259) WILL BE USED.	DEG F
336	0.0	CRITICAL FLUTTER MACH NO FOR T-TAIL VERT TAIL. MUST BE ZERO IF DATA MANAGEMENT DERIVED CTT VALUE IS TO BE USED.	
* 337	0.0	CRITICAL FLUTTER Q FOR T-TAIL VERT TAIL FLUTTER ANALYSIS. IF 0.0, CALC DATA MANAGEMENT Q WILL BE USED.	PSF
* 338	0.0	STRUCTURAL MATL G FOR T-TAIL VERT TAIL FLUTTER ANALYSIS. IF 0.0, CALC DATA MANAGEMENT G WILL BE USED.	PSI
* 339	0.0	FLUTTER REQMT COEFF. FLUTTER OVERSPEED FACTOR (D(252)) IF CTT CALC BY MODULE--D(336) IS INPUT NON-ZERO MACH NO. IF D(336) = 0.0, THIS VALUE MUST BE OF THE FORM CTT*FLUTTER OVERSPEED FACTOR SQUARED.	

NOTE: DATA LOC D(340) THRU D(345)--SURFACE PLANFORM GEOMETRY TO BE USED IN LIEU OF BASIC GEOMETRY DATA.
D(343) CAN BE USED TO SPECIFY EXPOSED SEMI-SPAN OTHER THAN THAT DERIVED FROM BASIC GEOMETRY IN FLUTTER REQMT CALC.

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
  340      0.0      WING AREA USED FOR GJ CALCULATIONS        SQ.FEET
  341      0.0      ASPECT RATIO FOR AREA IN D(340)
  342      0.0      TAPER RATIO FOR AREA IN D(340)
  343      0.0      FUSELAGE WIDTH FOR GJ CALCULATIONS.        INCHES
  344      0.0      THICKNESS RATIO AT CENTERLINE
  345      0.0      RATIO OF THICKNESS RATIOS. T/C AT TIP DIVIDED
                     BY T/C AT ROOT

  346-356  0.0      INPUT GJ OR COEFF.
                        OPTIONS: D(251)= 1.0 INPUT COEFF.
                                 D(251)= 2.0 INPUT GJ AT   LBS-IN-SQ
                                             STATIONS D(865)
                                             THRU D(875)

                        IF D(346) IS NON-ZERO ANY D(347)
                         THRU D(356) THAT IS=0.0 IS SET TO 1.0
                        IF D(346)=0.0  D(313)-D(316) ARE USED

* 357      0.0      ID TO BE USED ON V.TAIL RUN TO INDICATE A
                     T-TAIL. GIVES DIFFERENT GJ REQUIREMENTS FOR
                     VERTICAL.
                        OPTIONS: 0.0 NO T-TAIL OR TRANSFER
                                     OF DATA
                                 1.0 TEST DATA BLOCK(336,337,338,
                                     358,359,360) FOR TRANSFER
                                     OF T-TAIL DATA.

* 358      0.0      IYY PITCH INERTIA OF H.TAIL. USED FOR GJ
                     CALC. OF V.TAIL WHEN RUNNING A T-TAIL
                     ONLY.
                  -- IF D(357)&D(358)=0.0, TRANSFER DATA --

* 359      0.0      IXX ROLL INERTIA OF H. TAIL.-SEE D(358)
                     DESCRIPTION.
                  -- IF D(357)&D(359)=0.0, TRANSFER DATA --

* 360      0.0      IZZ YAW INERTIA OF H. TAIL. SEE D(358)
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		DESCRIPTION. -- IF D(357)&D(360)=0.0, TRANSFER DATA --
361	2.0	ID STRINGER TYPE FOR METALLIC DESIGN. OPTIONS: 0.0= I STRINGER 1.0= INTEGRAL Z 2.0= RIVETED Z NOTE: THIS CONTROL ID IS FOR MULTI-RIB STRINGER STIFFENED COVER DESIGN. THE MULTI-SPAR ID D(461) MUST BE ZERO.
362	4.0	BUCKLING COEFF. FOR SKINS--INFINITELY LONG PLATE SIMPLY SUPPORTED AT BOTH EDGES.
363	0.426	BULKLING COEFF. FOR I-STRINGER WEB AND Z-STRINGER FLANGES--INFINITELY LONG PLATE, SIMPLY SUPPORTED AT ONE EDGE, FREE AT THE OTHER.
364	4.0	BULKLING COEFF. FOR Z-STRINGER WEB
365	0.60	RATIO-MIN SKIN T TO T-BAR RECOMMENDED VALUE FOR MULTI-SPAR=0.05
366	0.75	RATIO-MAX SKIN T TO T-BAR RECOMMENDED VALUE FOR MULTI-SPAR=0.995
367	1.0	ID COMPRESSION COVER DESIGN DATA. OPTIONS: 0.0 NO INPUT 1.0 INPUT 2.0 INPUT FOR CONSTANT STRINGER SPACING IN D(765) THRU D(775) IF D(367)=2.0 AND D(383)=3.0 YOU HAVE CONSTANT STRINGER SPACING WITH D(380)=D(381)
368	1.0	ID TYPE OF ANALYSIS TO BE USED FOR COMPARISON OF REQD SECTION GJ(VF) TO AVAILABLE SECTION GJ(ST) AND FOR REQISING TO REQD GJ(VF). OPTIONS: 1.0 USE J COMPARISON WHERE J IS BASED ON THICKNESSES OF INDIVIDUAL REQD J WILL USE STEPWISE PROCEDURE OF SELECTING AND INCREASING THINNEST WEB FIRST.

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		2.0 USE T(VF) REQD COMPARISON WHERE T(VF) = (4*A*A/J*DS), CONSTANT FOR ALL WEBS. RESIZING WILL BE BASED ON INDIVIDUAL DELTA T.	
369	3.0	NO OF WEIGHT CALC PASSES FOR T-BOX ANALYSIS TO MINIMIZE DIFFERENCES IN ASSUMED TO CALC STRUCTURE DEADWEIGHT. VALUES FROM 0.0 TO 4.0 CAN BE USED. PROGRAM WILL ADD 1.0 TO ANY INPUT NO FOR THE FIRST GROSS WEIGHT ANALYSED. THE INPUTTED VALUE, WITH MIN VALUE OF 1.0 WILL BE USED FOR THE OTHER TWO GW, IF ANALYSED. NOTE: IF BOX OPTIMIZATION OPTION THRU ID IN D(1365) IS REQUESTED, THE NO OF DW PASSES MUST BE SET AT 3.0 OR 4.0.	
370	0.040	MIN GAGE-UPPER SKIN	INCHES
371	0.040	-STRINGER OR SPAR CAP(MULTI-SPAR)	INCHES
372	0.040	-RIB WEB OR INTERMED. SPAR WEB	INCHES
373	0.045	-FRONT SPAR WEB	INCHES
374	0.045	-REAR SPAR WEB	INCHES
375	10.0	MIN RIB SPACING OR SPAR SPACING FOR MULTI-SPAR.	INCHES
376	30.0	MAX RIB SPACING OR SPAR SPACING FOR MULTI-SPAR.	INCHES
377	0.75	MIN STRINGER HEIGHT OR CAP WIDTH FOR MULTI-SPAR.	INCHES
378	2.0	MAX STRINGER HEIGHT OR CAP WIDTH FOR MULTI-SPAR.	INCHES
379	1.0	MAX STRINGER FLANGE OR FLANGE OF CHANNEL CAP FOR MULTI-SPAR.	INCHES
380	1.0	MIN STRINGER SPACING OR SPAR SPACING FOR MULTI-SPAR.	INCHES
381	10.0	MAX STRINGER SPACING OR SPAR SPACING FOR MULTI-SPAR.	INCHES
382	4.0	MIN STRINGER NUMBER. NUMBER=(TIP WIDTH/ MAX STRINGER SPACING)-1.0	
383	0.0	ID STRINGER ORIENTATION	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                        OPTIONS: 1.0  OPTIMIZE
                                 2.0  CONSTANT NUMBER
                                 3.0  CONSTANT SPACING
384     0.4          MIN STRINGER FLANGE OR FLANGE OF CHANNEL   INCHES
                      CAP FOR MULTI-SPAR.

 ** SPECIAL NOTES FOR MULTI-SPAR RUNS:
        NO SEARCH IS MADE FOR MULTI-SPAR CONSTRUCTION
        YOUR INPUT WILL BE USED FOR THE CONSTRUCTION GEOMETRY

        D(377) AND D(378) MUST BE EQUAL. SUGGEST 1.0
        D(379) AND D(384) MUST BE EQUAL. SUGGEST 0.25
        D(375),D(376),D(380) AND D(381) MUST BE EQUAL
        D(383) CANNOT BE EQUAL TO 1.0
        IF D(383)=2.0:
                         SET D(375),D(376),D(380) AND D(381)=100.0
                         AND D(382)=WHOLE NUMBER OF SPARS YOU WANT.
        IF D(383)=3.0:
                         SET D(382)=1.0 AND D(375),D(376),D(380)
                         AND D(381)=SPAR SPACING YOU WANT.

                     NOTE: DESIGN STRESS DATA IN D(385) THRU D(388)
                           MUST BE TREATED AS ULTIMATE STRESSES.

385     1.0          UPPER COVER COMPRESSION CUTOFF STRESS
                         OPTIONS:  0.X FRACTION OF FCY
                                XXX.X CUTOFF STRESS                PSI
386     1.0          LOWER COVER TENSION CUTOFF STRESS
                         OPTIONS:  0.X FRACTION OF FTU
                                XXX.X CUTOFF STRESS                PSI
387     1.0          SHEAR STRESS CUTOFF
                         OPTIONS:  0.X FRACTION OF FSU
                                XXX.X SHEAR STRESS                 PSI
388     1.0          LOWER COVER COMPRESSION CUTOFF STRESS
                         OPTIONS:  0.X FRACTION OF FCY
                                XXX.X CUTOFF STRESS                PSI
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

389	0.0	MODULUS OF ELASTICITY E FOR LOWER COVER	
		OPTIONS: 0.0 USE UPP COVER E	
		XX.X E FOR LOWER COVER	PSI
390	0.0	DENSITY OF LOWER COVER	
		OPTIONS: 0.0 USE UPPER COVER DENSITY	
		0.XX DENSITY OF LWR COVER	LBS/CU IN
391	0.911	LOWER COVER EFFICIENCY FACTOR FOR COMPRESSION CHECK OF THE LOWER COVER.	
		OPTIONS: 0.65 FOR INTEGRAL I	
		1.05 FOR INTEGRAL Z	
		0.911 FOR RIVETED Z	
		0.785 FOR MULTI-SPAR	
392	0.600	MINIMUM RATIO -NZ/+NZ	
393	0.0	ID COLUMN EQUATION.	
		OPTIONS: 0.0 SHORT COLUMN EQ.	
		1.0 LONG COLUMN EQ.	
394	0.0	MIN GAGE LOWER SKIN	
		OPTIONS: 0.0 USES D(370)	
		0.X GAGE FOR LWR SKIN	INCHES
395	0.0	MIN RATIO OF SKIN T TO TBAR FOR LWR COVER	
396	0.3125	RIVET DIAMETER	INCHES
397	0.050	MIN PAD THICKNESS	
398	1.0	UPPER COVER TENSION CUTOFF STRESS	
		OPTIONS: 0.X FRACTION OF FTU	
		XXX.X CUTOFF STRESS	PSI
399	20.0	MAX NO OF INTERMEDIATE SPARS—ADV. COMP ONLY.	
		* D(400) THRU D(406)-INTERMEDIATE RIBS DATA OR INTERMEDIATE SPARS DATA WHEN MULTI-SPAR CONSTRUCTION.	
400	1.210	CORRUGATION FACTOR—120 DEG SINE WAVE	
401	0.40	LOCAL CRIPPLING FACTOR	
402	1.425	GENERAL INSTABILITY FACTOR	
403	0.50	MIN CORRUGATION RADIUS	
404	1.0	MAX CORRUGATION RADIUS	
405	2.0	CAP WIDTH	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

406	0.02	WEB GAGE INCREMENT FOR SEARCH	
407	1.0	COLUMN FIXITY COEFF FOR STRINGER COLUMNS--METALLIC COVER DESIGN. (VARIES FROM 1.0, PIN-ENDED TO 4.0, FIXED ENDED).	
408	0.590	CRIPPLING COEFF FOR PLATES SIMPLY SUPPROTED ON BOTH EDGES--SKIN PLATES AND Z-STR WEBS. USE: 0.590 FOR AL, 0.770 FOR TI.	
409	0.312	CRIPPLING COEFF FOR PLATES SIMPLY SUPPORTED ON ONE EDGE, FREE AT THE OTHER--I-STR WEBS AND Z-STR FLANGES. USE: 0.312 FOR AL, 0.304 FOR TI.	
410	1.025	WT FACTOR FOR MISC ATTACH PROV.--FRONT SPAR	
411	1.025	--REAR SPAR	
412	0.975	F.S. SHEAR ALLOWABLE OPTIONS: 0.X FRACTION OF FSU XXX.X SHEAR STRESS	LBS/SQ IN
413	0.975	R.S. SHEAR ALLOWABLE OPTIONS: 0.X FRACTION OF FSU XXX.X SHEAR STRESS	LBS/SQ IN
414	0.0	F.S. DENSITY-INPUT 0.0 IF=UPP COVER	LBS/CU IN
415	0.0	R.S. DENSITY-INPUT 0.0 IF=UPP COVER	LBS/CU IN
416	0.0	F.S. MODULUS OF ELASTICITY-INPUT 0.0=UPP COVER E	LBS/SQ IN
417	0.0	R.S. MODULUS OF ELASTICITY-INPUT 0.0=UPP COVER E	LBS/SQ IN
418	0.875	WIDTH-FS STIFFENER	INCHES
419	0.875	WIDTH-RS STIFFENER	INCHES
420	6.0	STIFF. SPACING FOR FS-YOU HAVE OPTION TO CHANGE.	INCHES
421	6.0	STIFF. SPACING FOR RS-YOU HAVE OPTION TO CHANGE.	INCHES

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

422	0.02	DELTA T FOR WEB GAGE SEARCH	INCHES
423	1.750	FACTOR FS CAP AREA = F(TEAR COVER)	
424	2.00	FACTOR RS CAP AREA = F(TEAR COVER)	
425	1.00	FACTOR FS WEB T BAR	
426	1.00	FACTOR RS WEB T BAR	
427	1.210	CORRUGATION FACTOR FS SINE WAVE DESIGN--ADV COMP	
428	1.2[illegible]	CORRUGATION FACTOR RS SINE WAVE DESIGN--ADV COMP	
		NOTE: DATA LOC D(429) THRU D(449) CONTROL AND ANALYSIS DATA FOR ADV. COMP OPTION.	
429	0.10	RATIO FOR NO OF 90 DEG PLIES (N-PLIES) TO TOTAL NO OF 0 AND 45 DEG PLIES (L,M PLIES).	
		NOTE: D(430) THRU D(439) ARE CONTROL ID FOR T-BOX SYNTHESIS AND DESIGN--ADV. COMP.	
430	0.0	ID TORQUE-BOX CONSTRUCTION, ADV. COMP DESIGN. REQUIRES SUPPLEMENTARY ID TO IDENTIFY COVER AND SUPPORT STRUCTURE TYPE. OPTIONS: 0.0=METALLIC ANALYSIS 1.0 MULTI-RIB/STRINGER. USE STR TYPE ID D(432)--UPPER COVER AND D(433)--LOWER COVER. 2.0 MULTI-SPAR/PLATE OR HC PANEL AND FULL DEPTH HC. USE TYPE ID D(431) FOR DETAILS.	
431	0.0	ID TYPE ID IF D(430)=2.0, MULTI-SPAR/FDH DESIGN OPTIONS: 1.0 M/S PLATE 2.0 M/S HC PANEL 3.0 FULL DEPTH HC	
432	0.0	ID UPPER COVER STRINGER TYPE IF D(430)=1.0 M/RIB OPTIONS: 1.0 INTEGRAL I-STR 2.0 INTEGRAL Z-STR 3.0 INTEGRAL T-STR 4.0 INTEGRAL HAT-STR 5.0 NOT USED	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
433    0.0    ID LOWER COVER STRINGER TYPE IF D(430)=1.0 M/RIB
                  OPTIONS: SAME AS UPPER COVER, D(432).
434    0.0    ID TYPE OF SEARCH FOR FOR ANALYSIS.
                  OPTIONS: 0.0 OPTIMIZE SKIN/CORE.
                           1.0 CONSTANT CORE, INPUT DENSITY.
                           2.0 VARIABLE CORE, CALC DENSITY FOR
                               SKIN GAGE SET BY ST REQMTS.

              NOTE: SPECIFY SUPT STRUCT CONST TYPE WITH DATA
                    CONTROL ID D(435) THRU D(439)

435    1.0    ID INTERMEDIATE SUPT STRUCT TYPE--RIB OR SPARS
                  OPTIONS: 1.0 SINE WAVE CORRUGATED WEBS
                           2.0 HONEYCOMB PANELS
                           3.0 FULL DEPTH HC, USED ONLY WHEN
                               D(430)=2.0 AND D(431)=3.0, FOR
436    1.0    ID FRONT SPAR STRUCT TYPE
                  OPTIONS: 1.0 SINE WAVE CORRUGATED WEB
                           2.0 HONEYCOMB PANEL
437    1.0    ID REAR SPAR STRUCT TYPE
                  OPTIONS: SAME AS FOR FRONT SPAR, D(436)
438    0.0    ID TYPE OF SEARCH FOR STRINGER OR SPARS
                  OPTIONS: 0.0 SEARCH FOR OPTIMUM SET OF STR
                               OR SPARS BASED ON STATUS OF
                               D(383), ID FOR OPT NO/SPACING
                           1.0 INPUT SPACING FOR STR OR INTERM
                               SPARS.  DATA IN D(765)-D(775)
                           2.0 INPUT NO OF STR OR INTERM SPARS
                               DATA IN D(776)-D(786)
439    0.0    NOT USED

              NOTE: DATA LOC D(440) THRU D(449) ARE CONST DATA
                    FOR MULTI-RIB/STRINGER ANALYSIS, ADV. COMP
                    COVER SYNTHESIS SEARCH.

440    2.0    MIN NO OF 0 DEG (L) PLIES--UPPER SKIN
441    2.0                             --LOWER SKIN
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

442	4.0	--UPPER COVER STRINGERS	
443	4.0	--LOWER COVER STRINGERS	
444	0.050	TOLERANCE, STRINGER (B/T)--AVAILABLE VS REQD.	
445	0.020	TOLERANCE, SKIN/STR 0 DEG PLY P/A STRESSES-- APPLIED VS ULT ALLOWABLE.	
446-449	0.0	NOT USED	
450	1.0	MODULUS OF ELASTICITY AT TEMP. TO BE USED FOR EI CALC. OPTIONS: 0.0 USE UPP COVER DATA 0.X FRACTION OF UPP COVER XX.X INPUT E	LBS/SQ IN
		* D(451) THRU D(454) HAVE THE SAME OPTIONS AS D(450)	
451	1.0	G AT TEMP. TO BE USED FOR GJ CALC. SEE D(450) OPTIONS	
452	1.0	G FOR LOWER COVER SEE D(450) OPTIONS	
453	1.0	G FOR FRONT SPAR SEE D(450) OPTIONS	
454	1.0	G FOR REAR SPAR SEE D(450) OPTIONS	
455	0.5	RATIO SKIN GAGE TO STRINGER GAGE-MAX	
456	0.5	-MIN	
		NOTE: DATA LOC D(457) THRU D(460) REQD FOR ADV. COMP OPTION ONLY.	
457	0.250	CAP FACTOR, INTERM SPARS, W/SPAR CONST	
458	0.0	CORE THICKNESS, INTERM RIBS OR SPARS HC PANEL DESIGN--D(435) = 2.0 ONLY.	IN
459	0.0	CORE THICKNESS, FRONT SPAR HC PANEL DESIGN--D(436) = 2.0 ONLY.	IN
460	0.0	CORE THICKNESS, REAR SPAR HC PANEL DESIGN--D(437) = 2.0 ONLY.	IN

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                    NOTE: DATA LOC D(461) = PRIMARY CONST TYPE ID
                          FOR METALLIC DESIGN ONLY.  HOWEVER, THIS
                          ID SHOULD BE COMPATIBLE WITH CONST TYPE
                          SPECIFIED FOR ADV. COMP DESIGNS.

461     0.0         ID TYPE CONSTRUCTION
                       OPTIONS: 0.0 STRINGER
                                1.0 PLATE(MULTISPAR)
                                2.0 HONEYCOMB PANEL
                                3.0 FULL DEPTH HONEYCOMB

                    NOTE: DATA LOC D(462) THRU D(469) = DESIGN DATA
                          FOR HONEYCOMB PANEL ANALYSIS--METALLIC
                          DESIGN.  NEED ALSO FOR ADV. COMP DESIGN
                          EXCEPT FOR D(463), CORE DENSITY.  CORE
                          DENSITY FOR ADV. COMP CALC FROM DATA SET
                          IN LOC D(1160)-D(1169), INH ARRAY.

462     0.5         CORE THICKNESS-UPPER COVER
                      OPTIONS: 0.0 FULL DEPTH
                               X.X DEPTH                       INCHES
463     6.0         CORE DENSITY                           LBS/CU FT
464     [illegible] BRAZE DENSITY FOR TWO FACE SHEETS      LBS/SQ FT
465     0.50        INSERT WIDTH FOR UPPER COVER
466     0.375       CORE THICKNESS-LOWER COVER
                      OPTIONS: 0.0 FULL DEPTH
                               X.X DEPTH                       INCHES
467     0.50        INSERT WIDTH FOR LOWER COVER               INCHES
468     1.0           INSERT WIDTH FOR ROOT RIB                    IN
469     0.075         INSERT DENSITY                        LB/CU IN

470     0.000222    PROTECTIVE FILM FOR ALL EXPOSED         LB/SQ IN
                     INTERNAL SURFACES--ADV. COMP ONLY.
                     UNIT WT FOR TWO SURFACES. (0.032 LB/SQ FT)

                    NOTE: DATA LOC D(471) THRU D(479) ARE BREAKPOINT
                          PRINT ID--STANDALONE VERSION.  DO NOT USE
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
471    0.0    PRINT ID-FUEL
                  OPTIONS: 0.0 NO PRINTOUT
                           1.0 COMPLETE PRINTOUT
                           2.0 CONDENSED PRINTOUT

472    0.0    PRINT ID-FUEL.
                  OPTIONS: 0.0 NO PRINTOUT
                           1.0 COMPLETE PRINTOUT
                           2.0 CONDENSED PRINTOUT

473    0.0    PRINT ID-DETAIL WT. SUMMARY.
                  OPTIONS: SAME AS D(471)

474    0.0    PRINT ID-
                  OPTIONS: SAME AS D(471)

475    0.0    PRINT ID-GENERAL DATA
                  OPTIONS: SAME AS D(471)

476    0.0    PRINT ID-GW(1) OUTPUT
                  OPTIONS: SAME AS D(471)

477    0.0    PRINT ID-GW(2) OUTPUT
                  OPTIONS: SAME AS D(471)

478    0.0    PRINT ID-GW(3) OUTPUT
                  OPTIONS: SAME AS D(471)

479    0.0    PRINT ID-FINAL SUMMARY
                  OPTIONS: SAME AS D(471)

480    1.0    ID WING CENTER SECTION.
                  OPTIONS:  0.0 NO WING CENTER SECTION
                            1.0 COMPUTE WIDTH
                          XXX.0 WIDTH OF CENTER          INCHES
                                SECTION-CHORDWISE
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		DISTANCE
		* D(480) THRU D(505) ARE WING CENTER SECTION WEIGHT COEFFICIENTS AND HAVE BEEN INITIALIZED TO A VALUE OF 1.0-YOU HAVE OPTION TO CHANGE ANY OF THESE VALUES.
481	1.0	W.C.S.-COEFFICIENT
482	1.0	-UPPER COVER COEFF.
483	1.0	-UPPER SKIN COEFF.
484	1.0	-UPPER STRINGER COEFF.
485	1.0	-LOWER COVER COEFF.
486	1.0	W.C.S.-LOWER SKIN COEFF.
487	1.0	-LOWER STRINGER COEFF.
488	1.0	-UPPER AND LOWER MISC-SKIN COEFF.
489	1.0	-ATTACHMENT COEFF.
490	1.0	-INTERMEDIATE RIB COEFF.
491	1.0	W.C.S.-INTERMEDIATE RIB-WEB COEFF.
492	1.0	-MISC. COEFF.
493		NOT USED
494	1.0	-FRONT SPAR-COEFF.
495	1.0	-CAP COEFF.
496	1.0	W.C.S.-FRONT SPAR-WEB COEFF.
497	1.0	-MISC. COEFF.
498	1.0	-REAR SPAR-COEFF.
499	1.0	-CAP COEFF.
500	1.0	-WEB COEFF.
501	1.0	W.C.S.-REAR SPAR-MISC. COEFF.
502	1.0	-CENTERLINE RIB-COEFF.
503	1.0	-CAP COEFF.
504	1.0	-WEB COEFF.
505	1.0	-MISC. COEFF.
506	0.0	FS LOC FOR CENTER-SECTION. <1.0 = X/C AT B1/2 >,=(+1.0) = INCHES AFT OF LE AT B1/2 (-N) = FUS STA. 0.0 = USE OPNL LOC
507-519	0.0	NOT USED

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

520	1.0	ID DELTA SHEAR TIE CALCULATION. OPTIONS: 0.0 NO CALCULATION. 1.0 CALC. SHEAR TIE DELTA WT.
521	0.0	DENSITY-SHEAR TIE MATL. OPTIONS: 0.0 USE DENSITY FROM INPUT MATERIAL. X.X INPUT DENSITY LBS/CU IN
522	1.0	FC MAX. FOR SHEAR TIE. OPTIONS: 0.0 USES INPUT MATL. FCY. <1.0 FRACTION OF INPUT MATL. FCY. >1.0 INPUT STRESS LEVEL LBS/SQ IN
523	1.0	FT MAX. FOR SHEAR TIE. SAME OPTIONS AS D(522) EXCEPT FTU REPLACES FCY.
524	1.0	FS MAX. FOR SHEAR TIE. SAME OPTIONS AS D(522) EXCEPT FSU REPLACES FCY.
525	1.0	FBR MAX. FOR SHEAR TIE. SAME OPTIONS AS D(522) EXCEPT FBRU REPLACES FCY.
526	141.3125	CONSTANT DATA-SHEAR TIE-C1
527	78.26	-C2
528	0.000025	-C3
529		NOT USED * D(530) THRU D(536) ARE PIVOT WEIGHT COEFFICIENTS-YOU HAVE OPTION OF CHANGING ANY OF THESE VALUES.
530	1.0	PIVOT-WEIGHT COEFF.
531	1.0	-INBOARD LUG WEIGHT COEFF.
532	1.0	-OUTBOARD LUG WEIGHT COEFF.

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

533	1.0	-PIN WEIGHT COEFF.
534	1.0	-INBOARD RIB WEIGHT COEFF.
535	1.0	-OUTBOARD RIB WEIGHT COEFF.
536	0.1	-MISC. WEIGHT COEFF.
537-549		NOT USED
		* D(550) THRU D(571) IS A TABLE OF SHEAR BUCKLING COEFFICIENT VERSES ASPECT RATIO.
550	0.0	ASPECT RATIO OF PLATE PT NO-1
551	0.1	-2
552	0.2	-3
553	0.3	-4
554	0.4	-5
555	0.5	-6
556	0.6	-7
557	0.7	-8
558	0.8	-9
559	0.9	-10
560	1.0	-11
561	4.25	SHEAR BUCKLING COEFF. FOR PT NO-1
562	4.50	-2
563	4.67	-3
564	4.86	-4
565	5.08	-5
566	5.35	-6
567	5.69	-7
568	6.10	-8
569	6.58	-9
570	7.15	-10
571	7.75	-11
572	0.05	EMPERICAL CONSTANT USED IN EQUATION TO DETERMINE BUCKLING COEFFICIENT WITH COMBINED SHEAR AND BENDING.
573	100.0	ID CONTROL FOR T/D ANALYSIS.

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		OPTIONS: 100.0 PURE SHEAR WEB ANALYSIS 1.0 COMBINED SHEAR AND BENDING ANALYSIS FOR THE WEB. NOTE: DATA LOC D(574) THRU D(578) ARE ID FOR BREAKPOINT PRINT DURING SYNTHESIS SEARCH FOR BOTH METALLIC AND ADV. COMP. AMOUNT OF PRINTED OUTPUT WILL BE DEPENDANT ON THE CONTROLS AND THE NUMBER OF CALC POINTS. FOR METALLIC DESIGN, IP(33) IS THE CONTROL ID FOR PRINT TEST. SINCE IP(33) IS A COMPLETE CASE ID, THE TEST WILL OCCUR DURING EVERY SURFACE ANALYSIS FOR THE CASE. FOR ADV. COMP DESIGN, LOC D(574) IS THE CONTROL ID FOR PRINT TEST--IP(33) IS NOT CHECKED.
574	0.0	ID DETAIL PRINT CONTROL, ADV. COMP ONLY. OPTIONS: 0.0 NO PRINT 1.0 PRINT ANALYSIS SUMMARY DATA AT EACH STATION ONLY FOR DW PASS NO IN D(578)--ALL CONST. 2.0 PRINT SUMMARY DATA PLUS DETAIL STR/SKIN LOAD DIST DATA FOR STR ANALYSIS ONLY DURING DW PASS NO OF D(578) AND FOR STATIONS INDICATED IN D(575), D(576) AND D(577). * LOC. 575-578 ARE USED WITH IP(33) TO INDICATE THE DEADWEIGHT PASS AND SECTIONS THAT WILL HAVE A DETAIL BREAK POINT AS OUTPUT.
575	0.0	SECTION TO HAVE DETAILED BREAK POINT PRINT, INDICATE ONE SECTION (Y(1)- Y(11)).

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

576	0.0	SECOND SECTION USED FOR BREAK POINT PRINT. INDICATE ONE SECTION (Y(1)- Y(11)).
577	0.0	THRID SECTION USED FOR BREAK POINT PRINT. INDICATE ONE SECTION (Y(1)- Y(11)).
578	0.0	INDICATE FOR NODW PASS TO HAVE DETAIL BREAK POINT DATA PRINTED. IT CAN BE EITHER 1,2,3 OR 4
579	0.999	CONSTANT DATA, ADV. COMP--ROUND CONSTANT FOR INTEGER NO OF 0, 45, 90 DEG PLIES/HALF LAMINATE
		NOTE: DATA LOC D(580) THRU D(596) FOR HONEYCOMB PROPERTIES VS TEMP CALC--DATA ARRAY CFMTL(5,3). BASE RATIOS FOR FOIL E,MU AND FCY VS 0, 100, 200, 300, 400 DEG F. REF TO 72 DEG F (ROOM TEMP). REF VALUES: E IN D(1165), MU IN D(595), FCY IN D(596).
		VALUES IN TABLE FOR 2024-T4 BARE AL SHEET. TABLE DATA MUST BE CHANGED IF DIFF CORE MATL IS TO BE USED.
580	102.5	CFMTL(1,1)--FOIL (E) VALUE, % OF D(1165), 0 DEG.
581	99.5	(2,1) , 100 DEG.
582	98.5	(3,1) , 200 DEG.
583	95.5	(4,1) , 300 DEG.
584	89.5	(5,1) , 400 DEG.
585	99.0	CFMTL(1,2)--FOIL MU VALUE, % OF D(595), 0 DEG.
586	100.2	(2,2) , 100 DEG.
587	101.7	(3,2) , 200 DEG.
588	103.2	(4,2) , 300 DEG.
589	104.5	(5,2) , 400 DEG.
590	102.5	CFMTL(1,3)--FOIL FCY VALUE, % OF D(596), 0 DEG.

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
591     99.5              (2,3)                       , 100 DEG.
592     96.5              (3,3)                       , 200 DEG.
593     91.5              (4,3)                       , 300 DEG.
594     82.0              (5,3)                       , 400 DEG.

595     0.350        CFENG--FOIL NU, REF VALUE AT ROOM TEMP, 7. DEG.
596     40000.0      CFTCY--FOIL FCY, REF VALUE AT ROOM TEMP       PSI
597     0.0003125    EXTERNAL PROTECTIVE COVER FOR ADV.      LB/SQ IN
                      COMP SKINS, AL FLAME SPRAY (0.045 PSF).
598     4.0          BUCKLING COEFF, ADV. COMP LONG PLATES, SIMPLY
                      SUPPORTED AT BOTH EDGES, SKINS AND STR WEBS.
599     1.0          BUCKLING COEFF, ADV. COMP LONG PLATES, SIMPLY
                      SUPPORTED AT ONE EDGE, FREE AT THE OTHER, 1-STR
                      WEB, Z- AND T-STR OUTSTANDING FLANGES

                     * D(600) THRU D(650) ARE THE WEIGHT INDEXING
                       COEFFICIENTS. YOU HAVE THE OPTION OF CHANGING
                       THESE VALUES-
                        OPTIONS:  0.0 WILL INPUT 1.0 INTO D(XXX)
                                 -1.0 WILL INPUT 0.0 INTO
                                      D(XXX)
                                  X.X WILL INPUT X.X INTO D(XXX)
                                  NO INPUT WILL LET PROGRAM USE
                                   INITIALIZED VALUES AS SHOWN
                                   BELOW.
        WING  HORIZ VERT
600     1.0   1.0   1.0    COEFFICIENT-TORQUE BOX
601     1.0   1.0   1.0               -LEADING EDGE
602     1.0   1.0   1.0               -TRAILING EDGE
603     0.025 0.020 0.030             -WING OUTER PANEL & WCS MISC.
604     1.075 1.075 1.075             -UPPER COVER

605     1.075 1.075 1.075  COEFFICIENT-UPPER SKIN
606     1.075 1.075 1.075             -UPPER STRINGER
607     1.10  1.08  1.07              -LOWER COVER
608     1.10  1.08  1.07              -LOWER SKIN
609     1.10  1.08  1.07              -LOWER STRINGER
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

	WING	HORIZ	VERT	
610	1.75	1.75	1.75	COEFFICIENT-UPP/LWR SKIN MISC.
611	2.0	2.0	2.0	-UPP/LWR SKIN ATTACH
612	1.75	1.10	1.10	-INTERMEDIATE RIB/SPAR
613	1.25	1.15	1.15	-INTERMEDIATE RIB/SPAR WEB
614	1.25	1.15	1.15	-INTERMEDIATE RIB/SPAR MISC.
615	1.25	1.25	1.25	COEFFICIENT-ATTACHMENT JOINT & BULKHEAD
616	1.10	1.10	1.10	-F.S.
617	1.15	1.15	1.15	-F.S. CAP
618	1.15	1.15	1.15	-F.S. WEB
619	1.15	1.15	1.15	-F.S. MISC.
620	1.10	1.10	1.10	COEFFICIENT-R.S.
621	1.15	1.15	1.15	-R.S. CAP
622	1.25	1.25	1.15	-R.S. WEB
623	1.15	1.15	1.15	-R.S. MISC.
624	1.50	1.10	1.10	-ROOT RIB
625	0.75	0.75	0.75	COEFFICIENT-ROOT RIB CAP
626	1.15	1.15	1.15	-ROOT RIB WEB
627	1.15	1.15	1.15	-ROOT RIB MISC.

628-638 NOT USED

639-649 1.0 K FACTORS FOR FCMAX ALLOWABLE AT EACH STATION. ARRAY = 1.0.

650-660 0.0 ID BULKHEADS. ONE BULKHEAD INSERT AT EACH SECTION INDICATED.
OPTIONS: 0.0 NO BULKHEAD
X.X DELTA COEFF. BULKHEAD WT.= (1.0+X.X) TIMES RIB WT.
IF SUM OF INPUTS IS LESS THAN 2.1 THEN D(655) IS SET = 2.0

661-671 0.0 ID CHORDWISE JOINTS.

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                     OPTIONS: 0.0 NO JOINT
                              X.X SPANWISE WIDTH FOR        INCHES
                                  ONE SIDE OF JOINT.
                              SUM OF INPUTS MUST BE > 3.1 IF
                              ROOT AND TIP ARE ZERO, OR
                              PROGRAM WILL SET D(661) AND
                              D(671)=1.0

672-685              NOT USED

                     NOTE: DATA LOC D(686) IS THE CONTROL ID TO INDI-
                           CATE INPUT LOADS AT THE 11 STRUCT. STA.
                           USE OF THIS ID REQUIRES APPROPRIATE DATA
                           IN DATA LOC D(260)-D(270), D(687)-D(719),
                           D(1019)-D(1040) AND D(953)-D(996).
                           THREE TYPES OF LOADS CAN BE INPUT:
                             A). GROSS LIMIT SHEARS AND MOMENTS, DATA
                                 BLOCKS D(260)-D(270), D(687)-D(719)
                                 AND D(1019)-D(1040).
                             B). NET LIMIT SHEARS AND MOMENTS, SAME
                                 AS (A) ABOVE.
                             C). COVER NX PLUS FRONT AND REAR SPAR
                                 FLOWS, Q, DATA BLOCK D(953)-
                                 D(996).  FOR THIS OPTION D(687) MUST
                                 BE SET TO 0.0.

                           LOGIC IN THE INPUT LOAD DATA PROCESS WILL
                           ALLOW FOR INPUT OF CONSTANT LOAD VALUES.
                           INPUT REQD VALUES FOR STA 1 ONLY AND SET
                           VALUE OF B. MOM FOR STA 2, LOC D(261) TO
                           0.0.

686      0.0         ID INPUT DESIGN LOADS AT 11 STRUCT. STATIONS.
                       OPTIONS: 0.0 NO INPUT, USE CALC LOADS.
                                1.0 INPUT LOADS, GROSS LIMIT.
                                2.0 INPUT LOADS, NET LIMIT.
                                3.0 INPUT LOADS, NX AND Q VALUES,
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		LIMIT. D(239) AND D(687) MUST BE SET TO 0.0.	
687-697	0.0	INPUT SHEAR, POSI. LOAD CONDITION, LIMIT D(687)=SECTION NO.1(ROOT) D(697)=SECTION NO.11(TIP)	LB
698-708	0.0	INPUT SHEAR, NEG. LOAD CONDITION, LIMIT D(698)=SECTION NO.1(ROOT) D(708)=SECTION NO.11(TIP)	LB
709-719	0.0	INPUT B. MOM, NEG. LOAD CONDITION, LIMIT D(709)=SECTION NO.1(ROOT) D(719)=SECTION NO.11(TIP) POSITIVE MOMENTS IN D(260)-D(270)	IN-LB
720	0.0	NOT USED.	
		NOTE: DATA BLOCKS IN LOC D(721) THRU D(841) WILL BE USED ONLY IF CONTROL ID IN D(367) IS A NON-ZERO NO. DATA IN THESE BLOCKS ARE USED TO SPECIFY DISCRETE DESIGN/SYNTHESIS VALUES AT EACH OF THE 11 STRUCTURAL STATIONS. THESE INPUTS WILL OVER-RIDE ALL BASIC INPUT IDENTIFIED BELOW AND ALL THE OPTIONAL ANALYSIS INPUTS BASED ON CONTROL ID DATA IN D(1301) AND D(1365).	
721-731	0.0	RATIO OF SKIN T TO TBAR -MIN REF. D(365)	
732-742	0.0	-MAX REF. D(366)	
743-753	0.0	SKIN THICKNESS-UPPER COVER	INCHES
754-764	0.0	-LOWER COVER	INCHES
765-775	0.0	MIN STRINGER SPACING. D(367)=2.0 FOR CONSTANT SPACING.	INCHES
776-786	0.0	MIN NUMBER STRINGERS.	
787-797	0.0	RIB SPACING	INCHES

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

798-808	0.0	STRINGER HEIGHT	INCHES
809-819	0.0	NUMBER OF STRINGER AREAS PER CAP-FS	
820-830	0.0	NUMBER OF STRINGER AREAS PER CAP-RS	
831-841	0.0	MIN RATIO -NX/+NX REF. D(392)	
842-852	1.050	FRONT SPAR SHEAR K FACTOR INITIALIZED TO 1.050, YOU HAVE OPTION TO CHANGE.	
853-863	1.200	REAR SPAR SHEAR K FACTOR INITIALIZED TO 1.20, YOU HAVE OPTION TO CHANGE.	

NOTE: DATA LOC D(864) IS THE CONTROL ID TO INDICATE INPUT T-BOX GEOMETRY FOR 11 STRUCT. STATIONS TO BE USED FOR SYNTHESIS. USE OF THIS CONTROL REQUIRES ALL THE GENERAL GEOMETRY DATA PLUS APPROPRIATE DATA IN DATA LOC D(865) THRU D(919).
THREE GENERAL OPTIONS ARE AVAILABLE WITH PROPER USE OF CONTROL AND DETAIL DATA:

A). INPUT OF STRUCT. STATION DEFINITION ONLY, PROGRAM CALC OF DETAIL SECTION GEOMETRY. REQUIRES NON-ZERO NO IN D(864), D(865)-D(875) AND 0.0 IN D(876).

B). INPUT OF COMPLETE STRUCT. GEOMETRY DATA. REQUIRES NON-ZERO NO. IN D(864) AND D(865)-D(919).

C). INPUT OF CONSTANT X-SECTION DATA AT ALL STATIONS. REQUIRES NON-ZERO NO IN D(864), D(865)-D(875), SECTION DATA FOR STATION 1 AND 0.0 IN D(877) --SECTION WIDTH FOR STATION 2.

864	0.0	ID INPUT T-BOX GEOMETRY SPECIFICATIONS. SEE NOTES ABOVE FOR DETAILS ON REQD DATA IN LOC	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                    D(865)-D(919).
                       OPTIONS: 0.0 NO INPUTS.  CALC GEOMETRY, SET
                                    UP 11 EQUALLY SPACED STRUCT.
                                    STATIONS BETWEEN BP STATION
                                    DEFINED BY D(246) FOR STA 1 AND
                                    D(139) FOR STA 11.
                                1.0 INPUT DATA.  STRUCT. STATION
                                    DATA DEFINED IN D(865)-D(875)
                                    REF TO BP STATION DEFINED BY
                                    D(246).
                                2.0 INPUT DATA.  SAME AS FOR ID=1.0
                                    EXCEPT THAT REF TO C/L.
                                3.0 INPUT DATA.  INPUT STATION
                                    VALUES ARE IN STRUCTURAL REF
                                    SYSTEM, 0.0 AT C/L.

865-875 0.0         INPUT STATIONS FOR STRUCTURAL SYNTHESIS.
                       OPTIONS: 0.XX FRACTION OF SPAN DEFINED BY
                                     REF INBD AND OBD STATIONS.
                                XX.X DELTA Y VALUES FROM REF      IN
                                       INBD STA IF D(864) = 1.0.
                                     BUTTOCK PLANE STA IF D(864)
                                       = 2.0
                                     STRUCTURAL STATIONS ALONG
                                       EA IF D(864) = 3.0.
                                NOTE:  IF THE INPUT STATION OPTION
                                       IS USED ONLY TO SPECIFY REQD
                                       STATIONS, LOCATION D(876)
                                       MUST BE SET TO 0.0.
                  --IF D(865)=0.0, SECTION CUTS TRANSFERED FROM DM--

876-886 0.0         STRUCTURAL WIDTH OF TORQUE BOX.              INCHES
887-897 0.0         AVERAGE DEPTH OF TORQUE BOX                  INCHES
898-908 0.0         TORQUE BOX DEPTH AT FRONT SPAR               INCHES
909-919 0.0         TORQUE BOX DEPTH AT REAR SPAR                INCHES

920-930 0.0         NOT USED
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

* IN THE SYNTHESIS PROCESS THE NX VALUES ARE MULTIPLIED BY D(931)-D(952) CONSTANTS TO REFLECT THE EFFECTS OF THE PEAK STRESSES OF THE TORQUE BOX WHICH OCCUR AT ITS CROWN. THEY WERE DETERMINED BY CORRELATION TO STRESS SIZING DATA.

931	1.175	K FACTOR TO UPPER COVER NX VALUE FOR SEC. NO.-1
932	1.15	-2
933	1.125	-3
934	1.11	-4
935	1.10	-5
936	1.09	-6
937	1.08	-7
938	1.07	-8
939	1.06	-9
940	1.05	-10
941	1.04	-11
942	1.075	K FACTOR TO LOWER COVER NX VALUE FOR SEC. NO.-1
943	1.065	-2
944	1.055	-3
945	1.045	-4
946	1.035	-5
947	1.025	-6
948	1.015	-7
949	1.005	-8
950	0.995	-9
951	0.985	-10
952	0.975	-11

NOTE: DATA BLOCK D(953)-D(996) IS THE INPUT BLOCK TO BE USED WHEN INPUT LOAD CONTROL ID D(686) = 3.0, INPUT NX AND Q. WHEN THIS OPTION IS USED D(239) AND D(687) MUST BE SET TO 0.0. FINAL DESIGN VALUES FOR NX AND Q WILL DIFFER SLIGHT-

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		LY FROM INPUT VALUES SINCE THE INPUTTED VALUES ARE CONVERTED TO SHEARS AND MOMENTS BY THE PROGRAM AND SUBSEQUENTLY RECALCULATED WITH COUPLE-ARM ADJUSTMENTS AS REQD. FOR THIS TYPE OF ANALYSIS, ONE DW PASS SHOULD BE SPECIFIED, D(369)=0.0 AND/OR VALUES INPUTTED FOR INITIAL COUPLE-ARMS IN DATA LOC D(997)-D(1007) AND D(1041)-D(1051).	
953-963	0.0	NOT USED	
964-974	0.0	NOT USED	
975-985	0.0	NOT USED	
986-996	0.0	NOT USED	
		* INPUTS FOR D(865)-D(1051) START WITH ROOT SECTIONS AND MOVE OUTBOARD.	
997-1007	0.0	DELTA Y-BAR UPPER COVER OPTIONS: 0.0 Y-BAR CALCULATED X.X INPUT Y-BAR	INCHES
1008-1018	1.0	K FACTORS FOR FTMAX ALLOWABLE AT EACH STATION. ARRAY = 1.0	
1019-1029	0.0	INPUT T. MOM, POSI. LOAD CONDITION, LIMIT	IN-LB
1030-1040	0.0	INPUT T. MOM, NEG. LOAD CONDITION, LIMIT	IN-LB
1041-1051	0.0	DELTA Y-BAR LOWER COVER OPTIONS: 0.0 Y-BAR CALCULATED X.X INPUT Y-BAR	INCHES
1052-1087		NOT USED	

NOTE: DATA LOC D(1088) THRU D(1119) = DATA ARRAY

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		[illegible](32). THIS BLOCK TO BE USED TO ADJUST CALC WEIGHT OF THE 10 T-BOX PANELS BY: A). DIFF WT FACTORS FOR EACH PANEL. B). DIFF DELTA WT TO BE APPLIED TO EACH CALC PANEL WT. USE THIS BLOCK TO REFINE T-BOX MASS DISTRIBUTION INERTIA CALC FOR DATA GENERATION OPTION. ALL INCREMENTAL WTS FROM THIS BLOCK WILL BE USED IN DW LOAD CALC AND IN FINAL T-BOX WT SUMMARY. WT COEFF IN D(6(4)-D(627) STILL APPLY.	
1088-1097	0.0	DELTA WT FACTOR FOR EACH T-BOX PANEL DEFINED BY STRUCTURAL STATIONS. IF EQUAL TO 0.0, ARRAY SET TO 1.0	
1098-1107	0.0	DELTA WT TO BE ADDED TO EACH T-BOX PANEL. ARRAY = 0.0.	LB/PNL
1108-1119	0.0	NOT USED	
		NOTE: DATA LOC D(1120) IS CONTROL ID FOR INPUT T-BOX MASS DIST. DATA FOR INITIAL DW CALC.	
1120	0.0	ID INPUT T-BOX WT/IN DATA. OPTIONS: 0.0 NO INPUT 1.0 INPUT T-BOX WT/IN AND/OR CONC. WTS AT EACH STRUCT. STATION.	
1121-1131	0.0	LBS/IN AT SECTION CUTS FOR TORQUE BOX	LBS/IN
1132-1142	0.0	CONC. WTS TO BE ADDED AT SECTION CUTS. ARRAY = 0.0.	LB/SIDE
		NOTE: DATA LOC D(1143) THRU D(1154) = DATA ARRAY DINT1(12). THIS BLOCK CONTAINS NO. AND SIZE	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		LIMITS FOR STRIP AND GRID CUTS FOR LE, TE AND TR PANEL TO CONTROL GRID SIZE DURING NUMERI-CAL INTEGRATION OF PANEL MASS DATA.
1143	15.0	MAX NO. OF STRIPS-INERTIA CALC. -BOX
1144	20.0	-LE
1145	20.0	-TE
1146	6.0	MIN STRIP WIDTH-INERTIA CALC. -BOX
1147	4.0	-LE
1148	4.0	-TE
1149	15.0	MAX NO. OF GRIDS-INERTIA CALC.-BOX
1150	20.0	-LE
1151	20.0	-TE
1152	6.0	MIN GRID LENGTH-INERTIA CALC. -BOX
1153	4.0	-LE
1154	4.0	-TE
1155-1204		NOT USED

NOTE: DATA LOC D(1155) THRU D(1204) CONTAINS MATERIAL PROPERTY DATA FOR ADV. COMP ANALYSIS.
D(1155)-D(1163) = ARRAY ENP(9), BASE PROPERTIES FOR LAMINA AT ROOM TEMP (72.0 DEG F).
D(1164)-D(1169) = ARRAY ENH(6), HONEYCOMB CORE PROPERTIES.
D(1170)-D(1204) = ARRAY TC(5,7), BASE PROPERTY VARIATION FACTORS VS TEMP (0,100,200,300,400 DEG) AS PER CENT OF ENP ARRAY ITEMS (1-7).

ARRAYS ENP AND TC CONTAINS PROPERTIES FOR BORON/EPOXY. IF DIFF ADV. COMP MATERIAL IS TO BE USED, DATA MUST BE CHANGED.

ARRAY ENH CONTAINS PROPERTIES FOR 2024-T4 BARE AL SHEET, COMPATIBLE WITH DATA IN ARRAY CEMTL, D(580)-D(594) AND ITEMS IN D(595) AND

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

D(596). FOR ADV. COMP ANALYSIS OF HC PNLS--COVERS AND WEB--ONLY ENH DATA ARE USED. FOR FULL-DEPTH HC ANALYSIS, ENH, CFMTL AND ITEMS IN D(595) AND D(596) ARE USED. APPROPRIATE DATA CHANGES MUST BE MADE IF DIFF TYPE OF CORE FOIL MATL IS REQD. CHANGES IN CORE CELL SIZE (S) AND FOIL GAGE (TF), DATA LOC D(1168) AND D(1169), CAN BE MADE WITHOUT OTHER CHANGES. CORE DENSITIES AND STIFFNESS CHARACTERISTICS ARE CALC BY THE PROGRAM.

1155	30000000.0	ENP(1)--ELASTIC MODULUS-LONGITUDINAL	PSI
1156	2700000.0	(2)--ELASTIC MODULUS-TRANSVERSE	PSI
1157	700000.0	(3)--SHEAR MODULUS	PSI
1158	0.210	(4)--POISSONS RATIO	IN/IN
1159	180000.0	(5)--ULTIMATE TENSION STRESS	PSI
1160	400000.0	(6)--ULTIMATE COMPRESSION STRESS	PSI
1161	67000.0	(7)--ULTIMATE SHEAR STRESS, 45 DEG PLIES	PSI
1162	0.0725	(8)--LAMINA THICKNESS	IN
1163	0.0050	(9)--LAMINA DENSITY	LB/CU IN
1164	0.100	ENH(1)--FOIL DENSITY	LB/CU IN
1165	10700000.0	(2)--FOIL MATL ELASTIC MODULUS	PSI
1166	4026000.0	(3)--FOIL MATL SHEAR MODULUS	PSI
1167	0.50	(4)--PANEL CORE THICKNESS--NOT USED	IN
1168	0.1875	(5)--CORE CELL SIZE	IN
1169	0.0020	(6)--FOIL GAGE	IN
1170	100.0	TC(1,1)--LAMINA (EL), % OF D(1155) VALUE, 0 DEG.	
1171	100.0	(2,1) , 100 DEG.	
1172	99.0	(3,1) , 200 DEG.	
1173	98.0	(4,1) , 300 DEG.	
1174	97.0	(5,1) , 400 DEG.	
1175	117.0	(1,2)--LAMINA (ET), % OF D(1156) VALUE, 0 DEG.	
1176	93.0	(2,2) , 100 DEG.	
1177	65.0	(3,2) , 200 DEG.	
1178	44.0	(4,2) , 300 DEG.	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1179	33.0	(5,2) , 400 DEG.
1180	110.0	(1,3)--LAMINA (GXY), % OF D(1157) VALUE, 0 DEG
1181	94.0	(2,3) , 100 DEG.
1182	75.0	(3,3) , 200 DEG.
1183	55.0	(4,3) , 300 DEG.
1184	37.0	(5,3) , 400 DEG.
1185	98.0	(1,4)--LAMINA MUXY, % OF D(1158) VALUE, 0 DEG.
1186	100.0	(2,4) , 100 DEG.
1187	102.0	(3,4) , 200 DEG.
1188	104.0	(4,4) , 300 DEG.
1189	106.0	(5,4) , 400 DEG.
1190	92.0	(1,5)--LAMINA FTU, % OF D(1159) VALUE, 0 DEG.
1191	89.0	(2,5) , 100 DEG.
1192	82.0	(3,5) , 200 DEG.
1193	65.0	(4,5) , 300 DEG.
1194	43.0	(5,5) , 400 DEG.
1195	103.0	(1,6)--LAMINA FCU, % OF D(1160) VALUE, 0 DEG.
1196	99.0	(2,6) , 100 DEG.
1197	85.0	(3,6) , 200 DEG.
1198	61.0	(4,6) , 300 DEG.
1199	5.0	(5,6) , 400 DEG.
1200	100.0	(1,7)--LAMINA FSU, % OF D(1161) VALUE, 0 DEG.
1201	100.0	(2,7) , 100 DEG.
1202	89.0	(3,7) , 200 DEG.
1203	77.0	(4,7) , 300 DEG.
1204	66.0	(5,7) , 400 DEG.
1205	0.0	WING FIXED LE UNIT WT. OPTIONS: 0.0 PROGRAM CALC. W/S FOR LE STATISTICALLY; X.X INPUT UNIT WT. LBS/SQ FT
1206	1.0	FACTOR FOR FIXED LE WING WT. YOU HAVE OPTION TO CHANGE.
1207	8.0	CONSTANT DATA-FIXED LE-WING
1208	1.5	-WING
1209	0.00077	-WING
1210	0.80	-WING

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1211	0.830	-WING
1212	0.10	-WING
1213	0.25	-WING
1214	0.10	-WING
1215	0.0	HORIZONTAL FIXED LE UNIT WT. SAME OPTIONS AS WING LE UNIT WT-D(1205)
1216	1.0	CONSTANT DATA-FIXED LE-H.TAIL
1217	8.0	-H.TAIL
1218	1.75	-H.TAIL
1219	0.0004	-H.TAIL
1220	0.80	-H.TAIL
1221	0.540	-H.TAIL
1222	0.10	-H.TAIL
1223	0.25	-H.TAIL
1224	0.10	-H.TAIL
1225	0.0	VERTICAL FIXED LE UNIT WT. SAME OPTIONS AS WING LE UNIT WT-D(1205)
1226	1.0	CONSTANT DATA-FIXED LE-V. TAIL
1227	8.0	-V. TAIL
1228	1.5	-V. TAIL
1229	0.0004	-V. TAIL
1230	0.80	-V. TAIL
1231	0.54	-V. TAIL
1232	0.10	-V. TAIL
1233	0.25	-V. TAIL
1234	0.10	-V. TAIL
1235	0.0	WING FIXED TE UNIT WT. OPTIONS: 0.0 PROGRAM CALC. W/S FOR TE STATISTICALLY. X.X INPUT UNIT WT. LBS/SQ FT
1236	1.0	CONSTANT DATA-FIXED TE-WING
1237	0.01	-WING
1238	1.0	-WING
1239	0.35	-WING

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1240	0.0165	-WING
1241	1.45	-WING
1242	1.0	-WING
1243	0.70	-WING
1244	950.0	-WING
1245	0.01	-WING
1246	0.0	-WING
1247	0.30	-WING
1248	0.25	-WING
1249	0.10	-WING
1250	0.0	HORIZONTAL FIXED TE UNIT WT. SAME OPTIONS AS WING TE UNIT WT-D(1235)
1251	1.0	CONSTANT DATA-FIXED TE-H. TAIL
1252	0.01	-H. TAIL
1253	1.0	-H. TAIL
1254	0.35	-H. TAIL
1255	0.0145	-H. TAIL
1256	1.35	-H. TAIL
1257	0.75	-H. TAIL
1258	0.70	-H. TAIL
1259	950.0	-H. TAIL
1260	0.01	-H. TAIL
1261	0.0	-H. TAIL
1262	0.10	-H. TAIL
1263	0.25	-H. TAIL
1264	0.10	-H. TAIL
1265	0.0	VERTICAL FIXED TE UNIT WT. SAME OPTIONS AS WING TE UNIT WT-D(1235)
1266	1.0	CONSTANT DATA-FIXED TE-V. TAIL
1267	0.01	-V. TAIL
1268	1.0	-V. TAIL
1269	0.35	-V. TAIL
1270	0.0145	-V. TAIL
1271	1.35	-V. TAIL
1272	0.75	-V. TAIL

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1273	0.70	-V. TAIL
1274	950.0	-V. TAIL
1275	0.01	-V. TAIL
1276	0.0	-V. TAIL
1277	[illegible]	-V. TAIL
1278	0.25	-V. TAIL
1279	0.10	-V. TAIL
1280	[illegible]	ULT LOAD FACTOR FOR CDL FTG WT EST. OPTIONS: 0.0 NZ TRANSFERRED FROM DR IF D(22)&D(1220)=0.0 X.X NZ YOU WANT CDL HARDPOINT WTS. BASED ON.
1281	1.0	NO. OF ATTACH PTS. FOR CDL NO.-1 INPUT 1 OR 2
1282	1.0	-2
1283	2.0	-3
1284	2.0	-4
1285	2.0	-5
1286	2.0	-6
1287	2.0	-7
1288	1.0	WT. FACTOR FOR CDL HARDPOINT WT.- CDL NO.-1
1289	1.0	-2
1290	1.0	-3
1291	1.0	-4
1292	1.0	-5
1293	1.0	-6
1294	1.0	-7
1295-1300		NOT USED
1301	0.0	IC DIFF COVER DESIGN CONSTRAINTS FOR EACH GROSS WT. DATA IN D(1302) THRU D(1322). 0.0 CONDITIONS FOR COVER REMAIN CONSTANT FOR ALL GROSS WTS. 1.0 INDICATES CONDITIONS MAY VARY-YOU MUST INPUT D(1302)

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		THRU D(1322).	
1302	0.0	MIN RIB SPACING-GW(1)	INCHES
1303	0.0	-GW(2)	INCHES
1304	0.0	-GW(3)	INCHES
1305	0.0	MAX RIB SPACING-GW(1)	INCHES
1306	0.0	-GW(2)	INCHES
1307	0.0	-GW(3)	INCHES
1308	0.0	MIN STRINGER HEIGHT-GW(1)	INCHES
1309	0.0	-GW(2)	INCHES
1310	0.0	-GW(3)	INCHES
1311	0.0	MAX STRINGER HEIGHT-GW(1)	INCHES
1312	0.0	-GW(2)	INCHES
1313	0.0	-GW(3)	INCHES
1314	0.0	MIN STRINGER SPACING-GW(1)	INCHES
1315	0.0	-GW(2)	INCHES
1316	0.0	-GW(3)	INCHES
1317	0.0	MAX STRINGER SPACING-GW(1)	INCHES
1318	0.0	-GW(2)	INCHES
1319	0.0	-GW(3)	INCHES
1320	0.0	MIN NUMBER OF STRINGERS-GW(1)	
1321	0.0	-GW(2)	
1322	0.0	-GW(3)	
		* FOR D(1320) THRU D(1322), NC.=(TIP WIDTH/ MAX STRG. SPACING)-1.0	
1323-1347		NOT USED	
		NOTE: DATA LOC D(1348) THRU D(1357) = CONSTANT DATA FOR STRINGER ANALYSIS, ADV. COMP.	
1348	1.0	STFNH(1)--NO OF STR WEBS--I-STR	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1349	1.0	(2) --Z-STR	
1350	1.0	(3) --T-STR	
1351	2.0	(4) --HAT-STR	
1352	0.0	(5) --NOT USED	
1353	0.0	STFNF(1)--NO OF STR FLANGES--I-STR	
1354	1.0	(2) --Z-STR	
1355	2.0	(3) --T-STR	
1356	1.0	(4) --HAT-STR	
1357	0.0	(5) --NOT USED	
1358-1364		NOT USED	
1365	0.0	INDICATOR FOR STRINGER OPTIMIZATION. OPTIONS: 0.0 NO OPTIMIZATION 1.0 OPTIMIZATION 2.0 CONSTANT NUMBER STRINGERS 3.0 CONSTANT STRINGER SPACING NOTE: SEARCH DATA IN D(1366) THRU D(1374) METAL. D(1369,1370,1373,1374) FOR ADV. COMP	
1366	6.0	SECTION OPTIMIZED WHERE DATA IS PRINTED.	
1367	6.0	MIN NO. STRINGERS	
1368	12.0	MAX NO. STRINGERS	
1369	2.0	INCREMENT USED IN SEARCH FROM D(1367) TO D(1368)	
1370	1.0	INCREMENT USED TO REDUCE OPTIMUM NO. SO THAT POINT MAY BE VARIFIED.	
1371	3.0	MIN STRINGER SPACING	INCHES
1372	5.0	MAX STRINGER SPACING	INCHES
1373	0.5	INCREMENT USED TO SEARCH FROM D(1371) TO D(1372)	INCHES
1374	0.25	INCREMENT TO REDUCE OPT. SPACING BY SO THAT IT MAY BE VARIFIED.	INCHES

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1375-1400		NOT USED		
			D(1401) THRU D(1500) = DATA ARRAY DC(100).	
1401	0.592079	CONSTANT DATA	-FT/SEC TO KNOTS	
1402	4.427635E-05		-DENSITY OF AIR AT SL	LBS/CU IN
1403	0.0		-CONSTANT ZERO	
1404	1.0		-K/EI-6J	
1405	35332.0		-ALTITUDE	
1406	971.1		-CS AT ALT. IN D(1405)	
1407	20786.0		-	
1408	0.3057		-	
1409	4.2561		-	
1410	0.000006375		-	
1411	0.00410236		-	
1412	1117.19		-CS AT S.L.	
1413	0.000000001		-CONSTANT (10)-9	
1414	1.0		-M/VF CUT-OFF	
1415	0.01		-X -Y	
1416	1.0		-E MIN	INCHES
1417-1431		NOT USED		
1432	-1.1160	CONSTANT DATA	-GJ CAL	
1433	1480.0		-GJ CAL	
1434	22.5		-GJ CAL	
1435	0.80		-GJ CAL	
1436	0.40		-GJ CAL	
1437	0.70		-GJ CAL	
1438	0.98481		-GJCAL, COS 10.0 DEG.	
1439	0.17365		- , SIN 10.0 DEG.	
1440	0.0	NOT USED		
1441	1.0		-GJ CAL	
1442	0.00001		-GJ CAL	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1443	32.174		-GJTT, ACCEL. CONST.
1444	25.98		-GJTT, ANALYSIS CONSTANT.
1445-1459		NOT USED	
1460	1.001	CONSTANT DATA	
1461	0.999	CONSTANT DATA	
1462-1469		NOT USED	
1470	0.6	CONSTANT DATA-SLCFS	
1471	1.3	-	
1472	0.156	-	
1473	1.0	-	
1474	1.0	-	
1475	0.188	CONSTANT DATA-DRIS	
1476	0.250	-	
1477	0.375	-	
1478	0.500	-	
1479	0.08	CONSTANT DATA-DBLO	
1480	0.156	-	
1481	1.21	-	
1482	1.375	-	
1483	1.05	-	
1484	4.0	-	
1485	0.375	-	
1486	1.0	-	
1487	0.125	-	
1488	1.333	-	
1489	1.75	-	
1490	0.5	CONSTANT DATA-DSPLI	
1491	2.5	-	
1492	1.0	-	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
1493      1.5                          -
1494      2.0                          -
1495      130000.0                     -
1496      0.288                        -
1497      4.5                          -
1498-                NOT USED
 1499

1500      0.0        ID LE DEVICE NO ONE.
                         OPTIONS: 0.0 NO DEVICE
                                  1.0 SLAT
                                  2.0 KRUGER
                                  3.0 DROOP NOSE
1501      0.0        NO. OF SEGMENTS FOR DEVICE NO. 1. YOU HAVE
                      THE OPTION OF ENTERING FROM 1 TO 3 SEGMENTS.
1502      0.0        SPANWISE LOC. FOR INBOARD EDGE OF DEVICE
                         OPTIONS:  0.X FRACTION OF SEMISPAN
                                  XX.X BUTTOCK PLANE            INCHES

1503      0.0        SPANWISE LOC. FOR OUTBOARD EDGE OF DEVICE.
                         OPTIONS: 0.X FRACTION OF SEMISPAN
                                  XX.X BUTTOCK PLANE            INCHES
1504      0.0        CHORDWISE DISTANCE FROM WING LE TO DEVICE
                      TE-INBD EDGE OF DEVICE
                         OPTIONS:  0.X FRACTION OF LOCAL TRAP.
                                       WING CHORD
                                  XX.X DISTANCE                 INCHES
1505      0.0        CHORDWISE DISTANCE FROM WING LE TO DEVICE
                      TE-OUTBD EDGE OF DEVICE
                         OPTIONS:  0.X FRACTION OF LOCAL TRAP.
                                       WING CHORD
                                  XX.X DISTANCE                 INCHES
1506      0.0        CHORDWISE DISTANCE FROM WING LE TO LE OF
                      FIXED WING STRUCT-INBD EDGE OF DEVICE
                         OPTIONS:  0.X FRACTION OF LOCAL TRAP.
                                       WING CHORD.
                                  XX.X DISTANCE                 INCHES
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1507	0.0	CHORDWISE DISTANCE FROM WING LE TO LE OF FIXED WING STRUCT-DUTED EDGE OF DEVICE OPTIONS: 0.X FRACTION OF LOCAL TRAP. WING CHORD XX.X DISTANCE	INCHES
1508		UNIT WT. FOR DEVICE. OPTIONS: 0.0 W/S IS GENERATED BY PROGRAM FROM STAT. DATA X.X INPUT W/S	LBS/SQ FT
1509	1.0	FACTOR FOR DEVICE NO. 1 WEIGHT	
		* D(1510) THRU D(1519) AND D(1520) THRU D(1529) BOTH HAVE THE EXACT SAME INPUT FORMATS AND OPTIONS AS D(1500) THRU D(1509)	
1510-1519	0.0	INPUT DATA FOR LE DEVICE NO. TWO-SEE INPUT OPTIONS FOR D(1500) THRU D(1509)	
1520-1529	0.0	INPUT DATA FOR LE DEVICE NO. THREE-SEE INPUT OPTIONS FOR D(1500) THRU D(1509)	
1530	1.0	CONSTANT DATA-LE DEVICE-SLAT	
1531	0.145	-SLAT	
1532	1.0	-SLAT	
1533	0.551	-SLAT	
1534	0.32	-SLAT	
1535	1.0	-SLAT	
1536	0.80	-SLAT	
1537	0.25	-SLAT	
1538	0.10	-SLAT	
1539	0.15	-SLAT	
1540	0.10	-SLAT	
1541	0.01	-SLAT	
1542	1.0	-SLAT	
1543	0.125	-SLAT	
1544	1.0	-SLAT	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1545	1.0	CONSTANT DATA-LE DEVICE-KRUGER
1546	1.5	-KRUGER
1547	1.0	-KRUGER
1548	0.413	-KRUGER
1549	0.32	-KRUGER
1550	0.667	-KRUGER
1551	0.80	-KRUGER
1552	0.25	-KRUGER
1553	0.10	-KRUGER
1554	0.25	-KRUGER
1555	0.10	-KRUGER
1556	0.01	-KRUGER
1557	0.75	-KRUGER
1558	0.125	-KRUGER
1559	1.0	-KRUGER
1560	1.0	CONSTANT DATA LE DEVICE-DROOP NOSE
1561	9.0	-DROOP NOSE
1562	1.725	-DROOP NOSE
1563	0.00077	-DROOP NOSE
1564	0.80	-DROOP NOSE
1565	0.330	-DROOP NOSE
1566	0.80	-DROOP NOSE
1567	0.25	-DROOP NOSE
1568	0.10	-DROOP NOSE
1569	0.25	-DROOP NOSE
1570	0.10	-DROOP NOSE
1571	0.01	-DROOP NOSE
1572	0.50	-DROOP NOSE
1573	0.125	-DROOP NOSE
1574	1.0	-DROOP NOSE
1575	0.830	-DROOP NOSE
1576-1579		NOT USED

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
1580    0.0    NO. OF SEGMENTS-SPOILER NO. ONE
                   OPTIONS: 0.0 NO SPOILER
                            X.0 NO. OF SEGMENTS-VALUE
                                CAN VARY FROM 1 TO 3.
1581    0.0    SPANWISE LOC. FOR INBD EDGE OF SPOILER
                   OPTIONS: 0.X FRACTION OF SEMISPAN
                            XX.X BUTTOCK PLANE                 INCHES
1582    0.0    SPANWISE LOC. FOR OUTBD EDGE OF SPOILER
                   OPTIONS: 0.X FRACTION OF SEMISPAN
                            XX.X BUTTOCK PLANE                 INCHES
1583    0.0    CHORDWISE DISTANCE FROM WING LE TO FWD
                EDGE OF SPOILER-INBD EDGE OF SPOILER
                   OPTIONS: <2.0 FRACTION OF LOCAL TRAP.
                                 WING CHORD.
                            >2.0 DISTANCE                      INCHES
1584    0.0    CHORDWISE DISTANCE FROM WING LE TO FWD
                EDGE OF SPOILER.OUTBD EDGE OF SPOILER
                   OPTIONS: <2.0 FRACTION OF LOCAL TRAP.
                                 WING CHORD.
                            >2.0 DISTANCE                      INCHES
1585    0.0    CHORDWISE DISTANCE FROM WING LE TO AFT
                EDGE OF SPOILER-INBD EDGE OF SPOILER
                   OPTIONS: <2.0 FRACTION OF LOCAL TRAP.
                                 WING CHORD.
                            >2.0 DISTANCE                      INCHES
1586    0.0    CHORDWISE DISTANCE FROM WING LE TO AFT
                EDGE OF SPOILER-OUTBD EDGE OF SPOILER
                   OPTIONS: <2.0 FRACTION OF LOCAL TRAP.
                                 WING CHORD.
                            >2.0 DISTANCE                      INCHES

1587    0.0    UNIT WT. FOR SPOILER NO. 1
                   OPTIONS: 0.0 W/S IS GENERATED BY
                                PROGRAM FROM STAT. DATA
                            X.X INPUT W/S                   LBS/SQ FT
1588    1.0    FACTOR FOR SPOILER NO.1 WEIGHT
1589    0.0    FACTOR FOR FIXED TE DELTA WEIGHT
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1590-1594		NOT USED
		* D(1595) THRU D(1604) SPOILER NO. 2 INPUT DATA HAS THE SAME FORMATS AND OPTIONS AS D(1580) THRU D(1589)-
1595-1604	0.0	INPUT DATA FOR SPOILER NO. TWO-SEE INPUT OPTIONS FOR D(1580) THRU D(1589)
1605-1609		NOT USED
		* WING,H.TAIL AND V.TAIL TE DEVICE WTS. ARE DETERMINED FROM INPUTS TO D(1610) THRU D(1729). INPUT LOCATIONS ARE AVAILABLE FOR 6 TE DEVICES. THE FIRST FOUR ARE USED BY THE WING, THE FIFTH BY THE H.TAIL AND THE SIXTH BY THE V.TAIL. DEVICES 1-3 WING TE FLAPS DEVICE 4 WING TE FLAP OR AILERON DEVICE 5 H.TAIL ELEVATOR DEVICE 6 V.TAIL RUDDER INPUT DATA D(1630) THRU D(1729) FOR DEVICES 2-6 REQUIRES THE SAME INPUT DATA AND OPTIONS AS D(1610) THRU D(1629).
1610	0.0	ID TE DEVICE NO. ONE OPTIONS: 0.0 SIMPLE FLAP 1.0 SINGLE SLOTTED FLAP 2.0 DOUBLE SLOTTED FLAP

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		3.0 TRIPLE SLOTTED FLAP
1611	0.0	NO. OF SEGMENTS-TE DEVICE NO. ONE OPTIONS: 0.0 NO DEVICE X.0 NO. OF SEGMENTS-VALUE CAN VARY
1612	0.0	SPANWISE LOC. FOR INBD EDGE OF DEVICE NO. ONE OPTIONS: 0.X FRACTION OF SEMISPAN XX.X BUTTOCK PLANE INCHES
1613	0.0	SPANWISE LOC. FOR OUTBD EDGE OF DEVICE NO. ONE OPTIONS: 0.X FRACTION OF SEMISPAN XX.X BUTTOCK PLANE INCHES
		* THE FOLLOWING OPTIONS ARE APPLICABLE TO INPUT LOCATIONS D(1614) THRU D(1627)- OPTIONS: <2.0 FRACTION OF LOCAL TRAP. WING CHORD. >2.0 DISTANCE IN INCHES
1614	0.0	CHORDWISE DISTANCE FROM WING LE TO FWD EDGE OF FIRST FLAP PANEL ON INBD BUTTOCK PLANE-SEE OPTIONS ABOVE
1615	0.0	SAME AS D(1614) EXCEPT ON OUTBD BUTTOCK PLANE
1616	0.0	CHORDWISE DISTANCE FROM WING LE TO AFT EDGE OF FIRST FLAP PANEL ON INBD BUTTOCK PLANE-SEE ABOVE OPTIONS
1617	0.0	SAME INPUT AS D(1616) EXCEPT FOR OUTBD BUTTOCK PLANE
1618	0.0	CHORDWISE DISTANCE FROM WING LE TO FWD EDGE OF SECOND FLAP PANEL ON INBD BUTTOCK PLANE-SEE ABOVE OPTIONS

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1019	0.0	SAME INPUT AS D(1018) EXCEPT FOR INBD BUTTOCK PLANE	
1020	0.0	CHORDWISE DISTANCE FROM WING LE TO AFT EDGE OF SECOND FLAP PANEL ON INBD BUTTOCK PLANE-SEE ABOVE OPTIONS	
1021	0.0	SAME INPUT AS D(1020) EXCEPT FOR OUTBD BUTTOCK PLANE	
1022	0.0	CHORDWISE DISTANCE FROM WING LE TO FWD EDGE OF THIRD FLAP PANEL ON INBD BUTTOCK PLANE-SEE ABOVE OPTIONS	
1023	0.0	SAME INPUT AS D(1022) EXCEPT FOR OUTBD BUTTOCK PLANE	
1024	0.0	CHORDWISE DISTANCE FROM WING LE TO TE OF FIXED WING UPPER SURFACE STRUCTURE ON INBD BUTTOCK PLANE-SEE ABOVE OPTIONS	
1025	0.0	SAME INPUT AS D(1024) EXCEPT FOR OUTBD BUTTOCK PLANE	
1026	0.0	CHORDWISE DISTANCE FROM WING LE TO TE OF FIXED WING LOWER SURFACE STRUCTURE ON INBD BUTTOCK PLANE-SEE ABOVE OPTIONS	
1027	0.0	SAME INPUT AS D(1026) EXCEPT FOR OUTBD BUTTOCK PLANE	
1028	0.0	UNIT WT. FOR DEVICE NO. ONE OPTIONS: 0.0 W/S CALC BY PROGRAM FROM STAT. DATA. X.X INPUT W/S	LBS/SQ FT
1029	1.0	FACTOR FOR DEVICE WEIGHT	
1030-1049	0.0	WING TE DEVICE NO. TWO-SEE D(1010) THRU D(1029) FOR INPUT DESCRIPTIONS.	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1650- 1669	0.0	WING TE DEVICE NO. THREE-SEE D(1610) THRU D(1629) FOR INPUT DESCRIPTIONS.
1670	0.0	ID TE DEVICE NO. FOUR OPTIONS: 0.0 SIMPLE FLAP 1.0 SINGLE SLOTTED FLAP 2.0 DOUBLE SLOTTED FLAP 3.0 TRIPLE SLOTTED FLAP 4.0 AILERON
1671- 1689	0.0	DEVICE NO. FOUR INPUT DATA-SEE D(1611) THRU D(1629) FOR INPUT DESCRIPTIONS.
1690-	0.0	ID TE DEVICE NO. FIVE-INPUT 5 IN D(1690) FOR H.TAIL ELEVATOR
1691- 1709	0.0	DEVICE NO. FIVE INPUT DATA-SEE D(1611) THRU D(1629) FOR INPUT DESCRIPTIONS.
1710	0.0	ID TE DEVICE NO. SIX- INPUT 6 IN D(1710) FOR V.TAIL RUDDER.
1711- 1729	0.0	DEVICE NO. SIX INPUT DATA-SEE D(1611) THRU D(1629) FOR INPUT DESCRIPTIONS.
1730	0.0	CONSTANT DATA TE-SPOILER
1731	1.0	-SPOILER
1732	0.008	-SPOILER
1733	0.8	-SPOILER
1734	1.95	-SPOILER
1735	0.10	-SPOILER
1736	0.25	-SPOILER
1737	0.10	-SPOILER
1738	0.01	-SPOILER
1739	1.0	-SPOILER
1740	0.125	-SPOILER
1741	1.0	-SPOILER
1742	0.45	-SPOILER
1743	0.15	-SPOILER
1744		NOT USED

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1745	0.001	CONSTANT DATA TE-FLAP
1746	0.65	-FLAP
1747	14.40	-FLAP
1748	0.25	-FLAP
1749	0.0	-FLAP
1750	1.0	-FLAP
1751	1.25	-FLAP
1752	1.50	-FLAP
1753	1.75	-FLAP
1754	0.10	-FLAP
1755	0.25	-FLAP
1756	0.10	-FLAP
1757	0.01	-FLAP
1758	0.25	-FLAP
1759	0.125	-FLAP
1760	1.0	-FLAP
1761	0.25	-FLAP
1762	0.125	-FLAP
1763-1764		NOT USED
1765	0.0	CONSTANT DATA TE-AILERON
1766	1.0	-AILERON
1767	0.01225	-AILERON
1768	0.35	-AILERON
1769	1.55	-AILERON
1770	0.50	-AILERON
1771	0.25	-AILERON
1772	0.10	-AILERON
1773	0.25	-AILERON
1774	0.10	-AILERON
1775	0.01	-AILERON
1776	0.10	-AILERON
1777	0.125	-AILERON
1778	1.0	-AILERON
1779	0.10	-AILERON

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1780	0.05	-AILERON
1781-1784		NOT USED
1785	1.40	CONSTANT DATA-ELEVATOR
1786	0.773	-ELEVATOR
1787	0.35	-ELEVATOR
1788	0.3069	-ELEVATOR
1789	0.0	-ELEVATOR
1790	1.50	CONSTANT DATA-RUDDER
1791	0.02442	-RUDDER
1792	0.35	-RUDDER
1793	1.36027	-RUDDER
1794	0.0	-RUDDER
1795	0.10	CONSTANT DATA-K SUPTS TYPE-SIMPLE
1796	0.28	-S. S.
1797	0.40	-D. S.
1798	0.55	-T. S.
1799	0.10	-AIL
1800	0.10	-ELE
1801	0.10	-RUD
1802	0.10	CONSTANT DATA-KXA AFT-SIMPLE
1803	0.15	-S. S.
1804	0.20	-D. S.
1805	0.20	-T. S.
1806	0.10	-AIL
1807	0.10	-ELE
1808	0.10	-RUD
1809	0.475	CONSTANT DATA-TAPER SUPT WT.-SIMPLE
1810	0.40	-S. S.
1811	0.30	-D. S.
1812	0.25	-T. S.
1813	0.475	-AIL

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
  1814      0.475                                      -FLF
  1815      0.475                                      -PUD

  1816-                 NOT USED
   1819

* 1820      0.0         WEIGHT TO BE DISTRIBUTED OVER THE TORQUE
                         BOX AREA-USED IN CALC. DEAD WEIGHT
                         DISTRIBUTION OF WING AND CONTENTS      LBS/SIDE
                      -- IF D(1820)=0.0, PORTION OF EQUIPMENT WT. --
                         WILL BE TRANSFER'D FROM G.D. IF YOU HEVE
                         NO WT. TO BE DISTRIBUTED OVER TORQUE BOX.
                         SUGGEST AN INPUT VALUE OF D(1820)=1.0

* 1821      0.0         WEIGHT OF WING CONTENT TO BE DISTRIBUTED
                         ALONG SECTION OF WING ON A LINE
                         DEFINED BY INPUT IN D(1822)-D(1828)    LBS/SIDE
                      -- IF D(1820)=0.0, SURFACE CONTROLS WT. FROM
                         G.D. IS TRANSFER'D. IF ONLY ONE LINE OF
                         DISTRIBUTED WEIGHT TO BE INPUT THEN USE
                         1821-1828.

* 1822      0.0         SPANWISE LOCATION OF INBD. POINT
                            OPTIONS: 0.X FRACTION OF SEMISPAN
                                     X.X BUTTOCK PLANE             INCHES
                      -- IF D(1823)=0.0, TRANSFER DATA --
* 1823      0.0         SPANWISE LOCATION OF OUTBD. POINT
                            OPTIONS: 0.0 D(1823) SET=1.0 AND LINE
                                         DIST. DATA BLOCK(1822-1827)
                                         WILL BE TRANSFERRED.
                                     0.X FRACTION OF SEMISPAN
                                     X.X BUTTOCK PLANE             INCHES

* 1824      0.0         CHORDWISE LOC. OF INBD. POINT
                            OPTIONS: 0.X FRACTION OF LOCAL CHORD
                                    XX.X FUSELAGE STATION          INCHES
                      -- IF D(1823)=0.0, TRANSFER DATA --
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

* 1825	0.0	CHORDWISE LOC. OF CUTRD. POINT OPTIONS: 0.X FRACTION OF LOCAL CHORD XX.X FUSELAGE STATION	INCHES
		-- IF D(1823)=0.0, TRANSFER DATA --	
* 1826	0.0	SPANWISE LOCATION OF INTERMEDIATE PT. ALONG LINE. OPTIONS: 0.X FRACTION OF LOCAL CHORD XX.X BUTTOCK PLANE	INCHES
		-- IF D(1823)=0.0, TRANSFER DATA --	
* 1827	0.0	TAPER RATIO OF WT. DISTRIBUTION FROM INBD PT. TO MID. PT.	
		-- IF D(1823)=0.0, TRANSFER DATA --	
1828	0.0	TAPER RATIO OF WT. DISTRIBUTION FROM MID PT. TO OUTBD. PT.	
		* IF YOU WISH TO USE ONE TAPER RATIO FOR THE TOTAL LENGHT THEN SET D(1826) AND D(1828) TO ZERO.	
1829	0.0	WEIGHT OF WING CONTENT TO BE DISTRIBUTED ALONG AFT SECTION OF WING ON A LINE DEFINED BY INPUT IN D(1830)-D(1836)	LBS/SIDE
1830-1836	0.0	INPUT DATA TO DEFINE LINE FOR DISTRIBUTION OF D(1829) WEIGHT-SAME INPUT REQUIREMENTS AS D(1822)-D(1828)	
1837	0.0	CONC. DEAD WT. NO. 1-USED AS PART OF WING CONTENTS FOR DEAD WEIGHT DIST.	LBS/SIDE
1838	0.0	SPANWISE LOCATION OF CONC. WT. NO. 1 OPTIONS: 0.X FRACTION OF SEMISPAN XX.X BUTTOCK PLANE	INCHES
1839	0.0	CHORDWISE LOCATION OF CONC. WT. NO. 1 OPTIONS: 0.X FRACTION OF LOCAL WING CHORD FROM LE XX.X FUSELAGE STATION	INCHES
		* D(1840) THRU D(1854), INPUT LOC. FOR	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

CONC. WTS. 2-6, WILL REQUIRE THE SAME INPUT DATA AS D(1837)-D(1839)

1840	0.0	CONC. WT. NO. 2	LBS/SIDE
1841	0.0	BUTTOCK PLANE	INCHES
1842	0.0	FUS. STATION	INCHES
1843	0.0	CONC. WT. NO. 3	LBS/SIDE
1844	0.0	BUTTOCK PLANE	INCHES
1845	0.0	FUS. STATION	INCHES
1846	0.0	CONC. WT. NO. 4	LBS/SIDE
1847	0.0	BUTTOCK PLANE	INCHES
1848	0.0	FUS. STATION	INCHES
1849	0.0	CONC. WT. NO. 5	LBS/SIDE
1850	0.0	BUTTOCK PLANE	INCHES
1851	0.0	FUS. STATION	INCHES
1852	0.0	CONC. WT. NO. 6	LBS/SIDE
1853	0.0	BUTTOCK PLANE	INCHES
1854	0.0	FUS. STATION	INCHES

* D(1855) THRU D(1935) ARE USED TO INPUT UP TO SEVEN EXTERNALLY MOUNTED CONC. WTS. COL 1 AND 2 ARE USED FOR WT. ITEMS WHICH ARE REMOVED FOR CERTAIN DESIGN CONDITIONS SUCH AS EXTERNAL FUEL AND MISSILES. COL 3 AND 4 MUST BE USED AS MOUNTS FOR COL 1 AND 2 WHEN 1 & 2 ARE REMOVED FOR SOME DESIGN CONDITION. COL 5-7 ARE USED FOR FIXED EXTERNAL STORE WTS.

-- NOTES FOR DATA TRANSFER --
WING PYLON AND EXT. TANK DATA WILL BE TRANSFERRED INTO COL NO.1,2,3 AND 4 IF DATA TRANSFER REQUIRED-

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                         WING MOUNTED NACELLE(S) DATA ARE TRANSFERRED
                         TO COL NO.5 AND 6 IF TRANSFER REQUIRED-
                         LG DATA IS TRANSFERRED TO COL NO.7 IF
                         TRANSFER REQUIRED-

* 1855     0.0          WT. COL NO.1-
                           OPTIONS:  0.0 NO CONC. WT.
                                    XX.X WEIGHT                 LBS/SIDE
                                   -XX.X WEIGHT-IF MINUS
                                         SIGN USED ONLY THE
                                         WING HARDPOINT WT. IS
                                         USED IN DIFFERENT
                                         DESIGN CONDITIONS.     LBS/SIDE
                      -- IF D(1855)&D(1856)=0.0 THEN WT. --
                         TRANSFERRED FROM DM.

* 1856                  SPANWISE LOC. FOR COL NO.1-
                           OPTIONS: 0.X FRACTION OF SEMISPAN
                                   XX.X BUTTOCK PLANE             INCHES
                      -- IF D(1856)=0.0 THEN COL NO.1 DATA BLOCK --
                         LOC. WILL BE TESTED FOR TRANSFER. ONLY
                         THE WT., X, Y, AND Z CG'S WILL BE TESTED
                         FOR TRANSFER.

* 1857     0.0          CHORDWISE LOC. FOR COL NO. 1
                           OPTIONS: 0<2 FRACTION OF LOCAL WING
                                        CHORD-DIST. AFT OF LE
                                     >2 DIST. AFT OF LE           INCHES
                                  0>-2 FRACTION OF LOCAL WING
                                        CHORD-DIST. FWD OF LE
                                    <-2 DIST. FWD OF LE           INCHES
                      -- IF D(1856)&D(1857)=0.0 THEN X CG TRANSFERRED --
                         FROM DM.

* 1858     0.0          VERTICAL DIST. TO COL 1 FROM WRP.
                           OPTIONS: -X.X DIST. BELOW WRP          INCHES
                                     X.X DIST. ABOVE WRP          INCHES
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

```
                    -- IF D(1856)&D(1858)=0.0 THEN Z CG TRANSFERRED --
                       FROM DM.

                    -- NOTE FOR DATA TRANSFER: THE INERTIA AND --
                       SHAPE FACTOR LOCATIONS (1860-1865) WILL
                       NOT HAVE TRANSFER DATA FOR ANY OF THE
                       FIRST FOUR COL ITEMS. COL NO.5 6 WILL
                       HAVE ALL LOCATED TESTED IF THEIR BLOCK
                       TRANSFER ID'S ARE ZERO. COL NO.7 WILL
                       ONLY HAVE THE WT,X,Y AND Z CG'S TESTED
                       IF ITS BLK. DATA ID IS ZERO.

 1859      0.0       INERTIA ID FOR COL 1-
                        OPTIONS: 0.0 INPUT IX,IY,&IZ IN
                                     D(1860)-D(1862)
                                 1.0 ID-CIRCULAR/ELLIPTICAL
                                     SHAPE
                                 2.0 ID-RECTANGULAR SHAPE
                                 3.0 NOT USED
                                 4.0 ASSUME SHAPE & K

*1860      0.0       PITCH INERTIA.IY FOR COL 1.
                        OPTIONS: IF D(1859)=0 INPUT IY        LB-IN-SQ
                                 IF D(1859)>0 D(1860)
                                    REPRESENTS SCALE FACTOR
                                    FOR CALC. IY.

*1861      0.0       ROLL INERTIA IX FOR COL 1-
                        OPTIONS: IF D(1859)=0 INPUT IX        LB-IN-SQ
                                 IF D(1859)>0 D(1860)
                                    REPRESENTS SCALE FACTOR
                                    FOR CALC. IX.

*1862      0.0       YAW INERTIA IZ FOR COL 1.
                        OPTIONS: IF D(1859)=0 INPUT IZ        LB-IN-SQ
                                 IF D(1859)>0 D(1860)
                                    REPRESENTS SCALE FACTOR
```

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		FOR CALC. IZ.
*1863	0.0	LENGTH OF SHAPE IN D(1859) OPTIONS: IF D(1859)=0 THEN SET D(1863)=0 IF D(1859)>0 INPUT LENGTH OF SHAPE IN D(1863) INCHES
*1864	0.0	WIDTH OF SHAPE IN D(1859) OPTIONS: IF D(1859)=0 THEN SET D(1863)=0 IF D(1859)>0 INPUT WIDTH OF SHAPE IN D(1863) INCHES
*1865	0.0	DEPTH OF SHAPE IN D(1859) OPTIONS: IF D(1859)=0 THEN SET D(1863)=0 IF D(1859)>0 INPUT WIDTH OF SHAPE IN D(1863) INCHES
1866	0.0	ID FOR PROCESSING DATA IN VF PROGRAM. OPTIONS: 0.0 VF PROG. WILL USE ONLY CDL #3OR#4 DATA SUBSETS. 1.0 CDL #1&#3 ARE PROCESSED TOGETHER AS ONE ADD-ON MASS AND CDL #2&#4 ARE PROCESSED AS ONE ADD-ON MASS.
		* D(1867) THRU D(1938), INPUT LOC. FOR CDL WTS. 2-7, WILL HAVE THE SAME INPUT FORMATS AND OPTIONS AS CDL #1 DATA LOC. D(1855)-D(1866).
* 1867- 1878	0.0	CDL NO. 2 INPUT DATA-SEE D(1855)-D(1866) FOR DATA DESCRIPTIONS.
		-- IF D(1868)=0.0 TEST CDL #2 DATA BLOCK -- LOCATIONS 1867-1870 FOR TRANSFER DATA

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

* 1879-1890	0.0	COL NO. 3 INPUT DATA-SEE D(1855)-D(1866) FOR DATA DESCRIPTIONS. * NOTE: IF BOTH COL 1&3 ARE USED THEN D(1856) & D(1880) MUST BE EQUAL -- IF D(1880)=0.0 TEST COL #3 DATA BLOCK -- LOCATIONS 1879-1882 FOR TRANSFER DATA
* 1891-1902	0.0	COL NO. 4 INPUT DATA-SEE D(1855)-D(1866) FOR DATA DESCRIPTIONS. * NOTE: IF BOTH COL 2&4 ARE USED THEN D(1868) & D(1892) MUST BE EQUAL -- IF D(1892)=0.0 TEST COL #4 DATA BLOCK -- LOCATIONS 1891-1894 FOR TRANSFER DATA
		FIRST FOUR COL ITEMS. COL NO. 5 & 6 WILL HAVE ALL LOCATIONS TESTED IF THEIR BLOCK * IF NACELLE DATA IS INPUT IN COL #1 AND #3 THEN 1904 AND 1916 MUST BE SET GREATER THAN ZERO OR NACELLE DATA FROM G.D. WILL BE TRANSFER'D.
* 1903-1914	0.0	COL NO. 5 INPUT DATA-SEE D(1855)-D(1866) FOR DATA DESCRIPTIONS. -- IF D(1904)=0.0 COL #5 DATA BLK. WILL BE -- TESTED FOR TRANSFER OF INBOARD NACELLE DATA FROM DM.
* 1915-1926	0.0	COL NO. 6 INPUT DATA-SEE D(1855)-D(1866) FOR DATA DESCRIPTIONS. -- IF D(1916)=0.0 COL #6 DATA BLK. WILL BE -- TESTED FOR TRANSFER OF OUTBOARD NACELLE DATA FROM DM.
		* IF LANDING GEAR IS INPUT IN EITHER COL #1 OR #3 THEN 1928 MUST BE SET GREATER THAN ZERO

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		[illegible]
[illegible]	[illegible]	CARD NO. 7 INPUT DATA-SEE [illegible] FOR DATA DESCRIPTIONS. -- IF [illegible] LOCATIONS -- [illegible] WILL BE TESTED FOR TRANSFER OF [illegible]
1939	[illegible]	CONSTANT DATA-CDL
1940	[illegible]	-CDL
1941	[illegible]	-CDL
1942	1.0	-CDL
1943	[illegible]	-CDL
1944	1.0	-CDL
1945	1.0	-CDL
1946	1.0	-CDL
1947	1.0	-CDL
1948	[illegible]	-CDL
1949	1000.0	-CDL
1950	1.0	-CDL
1951	2.5	-CDL
1952	[illegible]	-CDL
1953	[illegible]	-CDL
1954		NOT USED
1955	0.0	CONSTANT DATA-TIP
1956	1.0	-TIP
1957	0.00077	-TIP
1958	0.80	-TIP
1959	[illegible]	-TIP
1960	0.5	-TIP
1961	0.0	-TIP
1962	0.10	-TIP
1963	[illegible]	-TIP
1964	[illegible]	-TIP

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

1965-1969		NOT USED
1970	0.1155	CONSTANT DATA-K D SQ TERM-BOX
1971	0.0533	-LE
1972	0.0533	-TE
1973	0.0567	-TIP
1974	0.0533	-FUEL
1975	0.0500	-DIST. MISC.
1976	0.0400	-LINE MISC.
1977	0.0500	-CONC. MISC.
1978	0.75	* MAX DEPTH-FS
1979	0.90	-RS
1980	0.45	-LE
1981	0.80	-BOX MISC
1982-1984		NOT USED
		* D(1985) THRU D(2007) IS USED TO DEFINE THE COORDINATES OF BLENDED LEADING EDGE. THE LE IS DEFINED BY INPUTING BUTTOCK LOC. IN D(1985)-D(1995) AND THEIR CORRESPONDING CHORDWISE POSITIONS IN D(1997)-D(2007). THE LE SHAPE IS FORMED BY THE STRAIGHT LINE SEGMENTS WHICH CONNECT CONSECUTIVE POINTS. YOU CAN INPUT FROM ONE TO ELEVEN PTS.
1985-1995	0.0	BUTTOCK LOC. FOR BLENDED LE- OPTIONS: 0.X FRACTION OF SEMISPAN XX.X BUTTOCK PLANE INCHES
1996	0.0	ID INPUT DATA OPTIONS: 0.0 CHORDWISE DISTANCE IN INCHES IN D(1997)-D(2007) 2.0 FRACTION OF LOCAL TRAP.

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONT)

		CHORD IN D(1997)-D(2007) 1.0 INPUT FUS. STATION IN D(1997)-D(2007)	
1997- 2007	0.0	CHORDWISE LOC. FOR BLENDED LE- OPTIONS: IF D(1996)=0 INPUT DIST. FROM TRAP. LE TO BLENDED LE. IF D(1996)=1 INPUT FRACTION OF LOCAL CHORD FROM TRAP. LE TO BLENDED LE IF D(1996)=2 INPUT FUS. STA. OF LE POINT	INCHES INCHES
		* D(2008) THRU D(2030) ARE USED TO DEFINE THE COORDINATES FOR A CRANKED TE. THE TE IS DEFINED BY INPUTING BUTTOCK LOC. IN D(2008)-D(2018) AND THEIR RESPECTIVE CHORDWISE POSITIONS IN D(2020)-D(2030). THE TE SHAPE IS FORMED BY THE STRAIGHT LINE SEGMENTS WHICH CONNECT CONSECUTIVE POINTS. YOU CAN INPUT FROM ONE TO ELEVEN POINTS.	
2008- 2018	0.0	SPANWISE LOCATION FOR TE POINTS- OPTIONS 0.X FRACTION OF SEMISPAN XX.X BUTTOCK PLANE	 INCHES
2019	0.0	FORMAT ID-INPUTDATA OPTIONS: 0.0 CHORDWISE DIST. IN INCHES FOR D(2020)-D(2030) 2.0 FRACTION OF LOCAL TRAP. CHORD IN D(2020)-D(2030) 1.0 INPUT FUS.STATION IN D(2020) THRU D(2030)	
2020-	0.0	CHORDWISE LOC. FOR CRANKED TE POINTS-	

TABLE 8. D ARRAY, INPUT VARIABLE DATA (CONCL)

2030		OPTIONS: IF D(2019)=0 DIST. FROM TRAP. TE TO CRANKED TE	INCHES
		IF D(2019)=1 FRACTION OF LOCAL CHORD-TRAP. TE TO CRANKED TE.	
		IF D(2019)=2 FUS. STATION OF TE POINTS	INCHES
		* D(2031) THRU D(2052) ARE USED TO DEFINE THE BLENDED WING SPANWISE THICKNESS RATIOS. THE WING THICKNESS IS DEFINED BY INPUTING BUTTOCK LOC. IN D(2031)-D(2041) AND THEIR RESPECTIVE T/C VALUES IN D(2042) THRU D(2052). THERE IS A LINEAR VARIATION FOR THE DEPTHS BETWEEN CONSECUTIVE CALC DEPTHS AT THE CONTROL POINTS. YOU CAN INPUT FROM ONE TO ELEVEN CONTROL VALUES.	
2031-2041	0.0	SPANWISE LOCATION FOR T/C VALUES. OPTIONS: 0.X FRACTION OF SEMISPAN	
		XX.X BUTTOCK PLANE	INCHES
2042-2052	0.0	T/C VALUES-BASED ON TOTAL AERO CHORD	
2053-2060	0.0	NOT USED	

TABLE 9. ND ARRAY

General information for array ND:

Blank common reference location = 6121

Array size = 100 cells

Data type = Integer

Array ND contains integer constants in locations 1-20. Constants in these locations are initialized by subroutine CCNTL, overlay (8,0). Locations 21-100 are used as storage for index and analysis control code values.

Locations identified by an asterisk (*) are identified by various names. Refer to Table 13 for variable names used by each subroutine.

Array Location	Variable Name	Description
1	*	Constant, 1
2	*	Constant, 2
3	*	Constant, 3
4	*	Constant, 4
5	-	Constant, 5
6	-	Constant, 6
7	-	Constant, 7
8	-	Constant, 8
9	*	Constant, 9
10	*	Constant, 10
11	-	Constant, 11
12	-	Constant, 12
13	-	Constant, 120
14	-	Constant, 155
15	-	Constant, 190
16	-	Constant, 31
17	-	Constant, 61
18	-	Constant, 259
19	-	Constant, 18
20	-	Constant, 18
21	MATLI	Torque-box material number
22	ISC	Type of stringer/spar analysis, metallic designs. 1 = search for optimum, 2 = constant number, 3 = constant spacing

TABLE 9. ND ARRAY (CONTD)

Array Location	Variable Name	Description
23	IPA	Print code for design synthesis and weight analysis summary print (subroutine PRTA or ACPRTA output). 0 = no print, 1 = print.
24	IPB	Print code for synthesis and weight analysis details at each station (subroutines PRTB and PRTC output). 0 = no print, 1 = print.
25	NDWP	Number of dead weight iteration passes
26	*	Miscellaneous index values
27	*	Miscellaneous index values
28	*	Miscellaneous index values
29	*	Miscellaneous index values
30	*	Miscellaneous index values
31	*	Miscellaneous index values
	IWD	Code for type of torque-box geometry data, subroutine TBWDC, overlay (8,0). 1 = calculate, 2 = input.
32	*	Miscellaneous index values
	IFD	Code for flap type device identification subroutines TEDEV and TEWTI, overlay (14,0). 1 = TE flaps, 2 = aileron, 3 = elevator, 4 = rudder.
	IKI	Control code for subroutine BØT analysis under control of subroutine SFSCH, overlay (10,0). 1 = compute allowable compression stress level for specified (b/t) and t_{skin} values. 2 = compute allowable stress level where available (b/t) is equal to allowable (b/t).
	IL3	Point counter, t-skin search, subroutine TSCH, overlay (10,0).
33	IFK	Code for identification of type support for trailing edge device, subroutine TEDEV, overlay (14,0). 1 = spoilers, 2 = double-slotted flaps, 3 = triple-slotted flaps, 4 = see other types.

TABLE 9. ND ARRAY (CONTD)

Array Location	Variable Name	Description
	IP2	Print code for type of data blocks to be printed by subroutine PRTM, under control of subroutine MISCIT, overlay (15,0).
	IMØ	Control code for evaluation of section requirements, status condition specified in subroutine STBAR before return of control to subroutine TSCH (variable named IL2 in TSCH). 1 = specified t-skin OK, L(rib) less than L(max). 2 = t-skin OK, L(rib) set equal to L(max). 3 = available L(rib) less than L(min). 4 = available stringer area too small, cannot be distributed.
	IL2	Same as IMØ, subroutine TSCH.
	NSTIFF	Index code for type of stringers, upper and lower cover design, advanced composite multirib structures. 1 = integral "I." 2 = integral "Z", 3 = integral 'T", 4 = integral 'HAT."
34	IL	Logic control code for subroutine STBAR analysis. Value specified as 1 by subroutine TSCH (variable name IL1). 1 = do complete T-bar analysis, 2 = evaluate L(rib) requirements only. Code value 2 type currently not used.
	IL1	Same as IL, subroutine TSCH.
	ILS	Condition code for cover skin L-ply search, stringer design, advanced composite Multi-rib structures. 0 = initial point, 1 = second point, 2 = intermediate L-ply points, previous points indicate minimum total T-bar or higher L-ply values. 3 = minimum indicated between L-plies (i-1) and (i), 4 = last pass with L-ply (i) less 1.0 value. Recalculate to obtain final values.

TABLE 9. ND ARRAY (CONTD)

Array Location	Variable Name	Description
35	IM	Condition code for available stringer area, metallic design, subroutine STRG. Status specified by subroutine STRG before return of control to subroutine STBAR (variable name IMN). 1 = stringer area ok, 2 = stringer area too small.
	IMN	Same as IM, subroutine STBAR.
	NLS	Condition code for stringer L-ply search, critical buckling b/t evaluation, advanced composite multirib structures. 0 = initial pass with stringer L-ply value resulting from P/A evaluation, 1 = resize to larger stringer area, increase number of L-plies by 2.0, 2 = resize to smaller stringer area, decrease number of L-plies by 1.0.
36	NLR	Condition code for stringer L-ply search, critical column length evaluation, advanced composite multirib structures. 0 = initial pass with stringer L-ply values resulting from buckling (b/t) evaluation, 1 = available rib spacing too small, resize to larger stringer area, increase number of L-plies by 2.0, 2 = resize to smaller stringer area, decrease number of L-plies by 1.0.
37	IWEB	Index for front and rear spar, Metallic structures. 1 = front spar, 2 = rear spar.
	LSTRCR	Load condition number, critical buckling (b/t).
38	NI	Condition code for rib web gage search, metallic structures.
39	IK	Code for type of analysis by subroutine CG3P, metallic structures. 1 = parabolic fit and test for minimum condition, 2 = parabolic fit and compute value of x at Y = 1.0.
	KI	Same as IK.
40	IL	Condition code for minimum condition test by subroutine CG3P when IK is 1. Value specified by CG3P before return of control to subroutines SFSCH or TSCH, overlay (10.0). 1 = Minimum found at Y value stored in CXI, location TDC(47) = T(1347).

TABLE 9. ND ARRAY (CONT)

Array Location	Variable Name	Description
41	KFC	Condition code for starting stress level search, metallic structures. 1 = initial assumed values. 2 = initial assumed value OK, continue search for larger stress value.
	N1	Index code for web no. 1, first web to be used for section J increase, subroutine VFCAL, metallic structures flutter stiffness requirement analysis.
	ILCASE	Number of load conditions to be analyzed, advanced composite structures.
42	LF1	Location index for data set storage of analysis data contained in locations TSC(381)-TSC(415) for stress level point 1, TSS(10). 3 sets of 35-cell blocks stored in locations TSC(121)-TSC(224). Index value = 120, 155 or 190.
	N2	Index code for web No. 2, subroutine VFCAL. Refer to N1 in location 41.
	SKCØDE	Type code for cover design, advanced composite structures multispar for full-depth honeycomb sandwich designs. 1 = plate covers or full-depth honeycomb sandwich. If plate SPCØDE, ND(43) = 1 or 2, if full-depth honeycomb sandwich, SPCØDE = 3. 2 = honeycomb panel covers.
43	LF2	Location index for analysis data for stress level points 2, TSS(11), same as LF1, ND(42).
	N3	Index code for web No. 3. Refer to N1 and N2.
	SPCØDE	Construction code for internal torque-box substructure (intermediate spars and ribs), advanced composite structures. 1 = sine-wave corrugated webs, 2 = honeycomb panels, 3 = code for full-depth honeycomb sandwich design.
44	LF3	Location index for analysis data for stress level point 3, TSS(12), same as LF1 and LF2 (ND(42) and ND(43)).

TABLE 9. ND ARRAY (CONT)

Array Location	Variable Name	Description
	N4	Index code for web No. 4. Refer to N1, N2, and N3.
	TYPE	Control code for type of stringer/spar analysis, advanced composite structures. 1 = constant number of stringers or spars, 2 = constant stringer or spar spacing.
45	IØ1	Condition code No. 1 for assumed stress level, metallic design stress level search. Status specified by subroutine TSCH before return of control to SFSCH. 1 = stress level OK, 2 = stress too large, 3 = stress level OK, allowable rib spacing equal to or larger than L(max).
	ISK1	Same as IØ1, name used in TSCH.
	SFCØDE	Construction code for front spar, advanced composite structures. 1 = sine-wave corrugated webs, 2 = honeycomb panels.
46	IØ2	Condition code No. 2 for assumed stress level, metallic design stress level search. Status specified by subroutine TSCH before return of control to SFSCH. 1 = T-bar too small, 2 = available stringer area too small, 3 = available rib spacing less than L(min).
	ISK2	Same as IØ2, name used in TSCH.
	SRCØDE	Construction code for rear spar, advanced composite structures. 1 = sine-wave corrugated webs, 2 = honeycomb panels.
47	IMX	Index counter for stress level points, used by SFSCH during search for maximum allowable stress level search between a valid point and a higher stress level previously evaluated and identified as an invalid point.
	ICB	Condition code for bulkhead/joint analysis, subroutine BHDJT. 1 = joint at current station, 2 = no joint.
	IC	Control code for analysis logic, subroutine DLPVT. 1 = calculate weight, 2 = exit.

TABLE 9. ND ARRAY (CONT)

Array Location	Variable Name	Description
48	IC	Control code for analysis logic, subroutine WTCAL. 1 = initial station, calculate section cross-sectional area data only, 2 = stations 2-11, calculate section cross-sectional area data for current station and determine panel weights.
49	ICD	Control code for torque-box section design data, metallic structures. 1 = no station-station inputs, 2 = input data for 11 analysis control stations.
50	IDVF	Control code for stringer/spar arrangement logic, flutter analysis pass, subroutine SECTD. Values setup during initial strength analysis pass.
51	IVF	Control code for flutter analysis pass, metallic structures. Used by subroutines SECTD, SFSCH, TSCH and EIGJC to determine if current sizing data are for strength or resizing for flutter requirements. Initialized to 1.0 by CNSTR, set to 2.0 by SECTD or VFCSC if any of 4 torque-box webs are flutter stiffness critical to indicate resizing required. Code value of 3 currently not specified; test logic set up to treat code value of 3 as input t(SKIN) at all 11 analysis control station.
	IDSK	Same as IVF, name used in TSCH.
52	IB	Condition code for number of stringers/spar passes, SECTD/SFSCH logic, metallic structures. 1 = initial value for assumed number, 2 = second and subsequent passes.
53	IVFJT	Control code for type of section stiffness, (J), analysis to be used for flutter stiffness penalty evaluation, metallic structures. 1 = (J) comparison, nonequal web thicknesses, 2 = flutter stiffness penalty evaluation based on constant web gage required for flutter.

TABLE 9. ND ARRAY (CONT)

Array Location	Variable Name	Description
54	LID	Control code for type of design loads. Value of 2 assigned if SWEEP calculated loads are to be used (D(205), SLDID=1.0). If SWEEP calculated loads are not to be used (D(205)=0.0), then code values are: 1 = calculate gross airloads, subroutine ALØAD, 2 = input gross limit airload shears, bending moments and torsional moments, 3 = input net design shears and moments.
55	ISEC	Index counter for analysis control stations. (1-11) = root to tip, overlay (8,0). (1-11) = tip to root, overlay (10,0) and subroutine ACNSTR, overlay (18,0).
	NSTAT	Index counter for analysis control stations, advanced composite structures. (1-11) = tip to root.
56	NØDW	Dead weight pass counter
57	IGT	Gross-weight counter
	IGW	Gross-weight counter
58	-	Not used
59	NMATL	Number of material property data sets in material properties library
60	NCASE	Case counter
61	IGW	Gross-weight counter, same as ND(57) above.
62	ISEC	Index counter for analysis control stations, advanced composite structures. (1-11) = root to tip.
63	-	Not used
64	-	Not used
65	-	Not used
66	ILWRC	Control code for lower cover analysis, metallic structures, subroutine SECTD, overlay (10,0)
67	NAF	Index code for number of X/C points in array DAF airfoil tables.
68	NCSEC	Control code for torque-box analysis: 1 = standard outer-panel type analysis. 2 = constant cross-section, constant load at all stations (center-section type, do tip section only).

TABLE 9. ND ARRAY (CONT)

Array Location	Variable Name	Description
69	-	Not used
70	IRG	Control code for stringer sizing logic, metallic structures. Value identifies the relative location of the required stringer web/flange (b/t) to the control values of (b/t) for a particular stringer type, stringer spacing, and stringer geometry limits. Subroutine STRG uses this code value to determine the applicable stringer sizing equations to be used to compute web thickness, web heights and flange widths, if applicable.
71	IMX	Control code for stringer sizing logic, metallic structures. Value identifies Z-type stringer element (web or flange) that is critical for buckling (b/t) when the element size is at the maximum allowable value. 1 = web, 2 = flange.
72	IBT	Control code for stringer sizing logic, metallic structures (riveted "Z" stringers). Similar to IMX above for identifying critical (b/t) element. 1 = web for maximum height, 2 = flange at minimum width.
73	IØPT	Condition code analysis point during optimization analysis of total torque box, metallic structures. Used by subroutine TBØPT to determine logic path during search and, if applicable, for output print of analysis results.
74	IØPI	Identification code for optimum analysis point determined during optimization of total torque-box for assumed values of stringer/spar spacings or numbers, metallic structures, used by subroutine TBØPT when control code IOP1, ND(82), is specified as 2, 3, 4, or 5.
75-79	IØPD	Five-cell array for tracking of analysis points evaluated during total torque-box optimization by subroutine TBØPT, under control of control code IØP1, ND(82).

TABLE 9. ND ARRAY (CONT)

Array Location	Variable Name	Description
80	IØPJ	Control code, analysis control station value to be used for total torque-box optimization for separate optimization of the inboard and outboard sections of the torque-box to different search limits for stringer/spar spacings or numbers. Currently initialized and tested, but the optimization logic is not available.
81	IØPP	Point counter, used to track current point for which analysis data is being printed.
82	IØP1	Control code for torque-box optimization logic, metallic structures. 1 = no optimization search control in subroutine TBØPT. 2-5 = total torque-box optimization under control of TBØPT logic. 2 = optimize using constant number of stringer/spar elements, 3 = optimize using constant stringer/spar spacings. 4 and 5 are currently not used.
83	IØPS	Temporary storage location for initial value of ISC, ND(22).
84	IØPC	Temporary storage location for initial value of ICD, ND(49).
85	NPAGE	Page counter for summary data printed output
86	ISG	Point counter to identify calls to subroutine TSCH by SFSCH, printed to identify data sets printed by subroutine PRTBK.
87	ISTB	Point counter to identify calls to subroutine STEAR by TSCH, printed to identify data sets printed by subroutine PRTBK.
88	ISTRG	Identification code to identify logic statement number in subroutine STRG, printed to identify data sets printed by subroutine PRTBK.
89	-	Not used
90	-	Not used
91	-	Not used
92	IF3	Mass storage file 1 record number for material property data set to be used by subroutines MTLCW and MTLFW.

TABLE 9. ND ARRAY (CONCL)

Array Location	Variable Name	Description
93	IF4	Temporary location for mass storage file 1 record number used during storage and retrieval of analysis results.
94	-	Not used
95	-	Not used
96	-	Not used
97	IF8	Temporary location for mass storage file 1 record number used during storage and retrieval of analysis results.
98	-	Not used
99	-	Not used
100	-	Not used

TABLE 10. DC ARRAY, MISCELLANEOUS CONSTANTS

General information for array DC:

Blank common reference location = D(1401)

Array size = 100 cells

Array contains miscellaneous program constants, constants for flutter analysis, data generation option, and torque box synthesis. Sub-array names SLCFS, DR1S, DBLØ, and DSPLI are assigned to this array to identify torque box structural analysis constants. Variable names DFREIK, CØS10, SIN10, GØ, PT4, PT7, and PT8 are used to reference array locations. General constants 0.0 and 10^{-9} are located in DC(3) and DC(13).

This array is part of the D array; initial values are contained in the wing deck of the SWEEP permanent data bank. All initial array values can be changed by revising the permanent data deck or through D array reference cards in the input variable data decks for wing and empennage, locations D(1401) through D(1499). (Note: DC(100) or D(1500) is used by array DLED1.)

Array Loc	Data Bank Value	Location Ref: Variable Name	Location Ref: Size	Description
1	0.592079	-	-	Conversion factor ft/sec to knots
2	0.00004427635	-	-	Density of air at sea level, lb/cu in.
3	0.0	-	-	Constant 0.0
4	0.001	DFREIK	1	Factor for EI value, front and rear spar caps
Locations 5-12 contain constant for calculations of properties of atmosphere.				
5	35332.0	-	-	Altitude cutoff, ft
6	971.1	-	-	Velocity of sound above cutoff altitude, ft/sec
7	20,786.0	-	-	Constant, altitude ≥35332.0

TABLE 10. DC ARRAY, MISCELLANEOUS CONSTANTS (CONT)

Array Loc	Data Bank Value	Location Ref		Description
		Variable Name	Size	
8	0.3057	-	-	Constant, altitude ≥35332.0
9	4.2561	-	-	Constant, altitude
10	0.000006875	-	-	Constant, altitude <35332.0
11	0.0041023567	-	-	Constant, altitude <35332.0
12	1117.1853	-	-	Velocity of sound at sea level, ft/sec
13	0.000000001	-	-	Constant 10^{-9}
14	1.0	-	-	Default value of flutter cutoff speed, data generation for flutter optimization program, M
15	0.01	-	-	ϵ_Y, fraction of station distance for minimum station increment for inclusion of add-mass control station, data generation for flutter optimization program.
16	1.0	-	-	ϵ_Y, minimum station increment for inclusion of add-mass control station, data generation for flutter optimization program, in.
17-31	0.0	-	-	Not used
32	-1.1160	-	-	Empirical constant, flutter requirement equation

TABLE 10. DC ARRAY, MISCELLANEOUS CONSTANTS (CONT)

Array Loc	Data Bank Value	Location Ref		Description
		Variable Name	Size	
33	1480.0	Q0	1	Dynamic pressure Q at sea level, constant for flutter requirement calculations
34	22.5	-	-	Empirical constant flutter requirement equation
35	0.8	PT8	1	Empirical constant, flutter requirement equation
36	0.4	PT4	1	Empirical constant, flutter requirement equation
37	0.7	PT7	1	Empirical constant, flutter requirement equation
38	0.98481	CØS10	1	Cos 10°, constant, flutter requirement equation
39	0.17365	SIN10	1	Sin 10°, constant, flutter requirement equation
40	0.0	-	-	Not used
41	1.0	-	-	Flutter requirement factor
42	0.00001	-	-	Minimum values for λ, σ' or $\lambda'\sigma'$, constant for flutter requirement analysis
43	32.174	GOFPS	1	Acceleration constant, ft/sec
44	25.88	VTK	1	Empirical constant, T-tail vertical tail flutter requirement equation
45-59	0.0	-	-	Not used

TABLE 10. DC ARRAY, MISCELLANEOUS CONSTANTS (CONT)

Array Loc	Data Bank Value	Location Ref: Variable Name	Location Ref: Size	Description
60	1.001	-	-	Search tolerance for b/t
61	0.999	-	-	Search tolerance for b/t
62-69	0.0	-	-	Not used
(70-74)		(SLCFS)	(5)	Subarray SLCFS, blank common reference = D(1470)
70	0.600	SLCFS(1)	-	ΔL_{FS}, cover overhand width at front spar for average cover N_X, in.
71	1 300	SLCFS(2)	-	ΔL_{RS}, cover overhang width at rear spar for average cover N_X, in.
72	0.156	SLCFS(3)	-	t_{cap} min, minimum front and rear spar cap gage, 0.156 for aluminum and adv comp, 0.100 for titanium, in.
73	1.000	SLCFS(4)	-	Factor, average t_{cap} approximation
74	1.000	SLCFS(5)	-	Factor, effective $\bar{t}$ width for cover overhang at front and rear spars, for average cover N_X
(75-78)	-	(DRIS)	(4)	Subarray DRIS, blank common reference = D(1475)
75	0.188	DRIS(1)	-	Fastener diameter, ribs and stringers for net tension area calculations, in.
76	0.250	DRIS(2)	-	Fastener diameter, intermediate spars for net tension area calculations, in.

TABLE 10. DC ARRAY, MISCELLANEOUS CONSTANTS (CONT)

Array Loc	Data Bank Value	Location Ref: Variable Name	Location Ref: Size	Description
77	0.375	DRIS(3)	-	Fastener diameter, front and rear spars for net tension area calculations, in.
78	0.500	DRIS(4)	-	Fastener diameter, root rib, in.
(79-89)	-	(DBLØ)	(11)	Subarray DBLØ, blank common reference = D(1479)
79	0.080	DBLØ(1)	-	$t_{web\ min}$, minimum web gage, bulkheads and root rib, in.
80	0.156	DBLØ(2)	-	$t_{cap\ min}$, minimum cap gage, bulkheads and root rib, in.
81	1.210	DBLØ(3)	-	corrugation/stiffener factor, bulkheads and root rib
82	1.375	DBLØ(4)	-	L_{cap}, bulkhead cap length, in.
83	1.050	DBLØ(5)	-	Area factor, bulkhead caps and webs
84	4.000	DBLØ(6)	-	Fastener spacing factor, number of fastener diameter, bulkheads and root rib
85	0.375	DBLØ(7)	-	Fastener diameter, bulkheads
86	1.000	DBLØ(8)	-	K_T, fastener hole factor, net tension area for bulkhead attach skin pad calculations
87	0.125	DBLØ(9)	-	$t_{pad\ min}$, minimum skin pad gage, bulkhead attach, in.

TABLE 10. DC ARRAY, MISCELLANEOUS CONSTANTS (CONT)

Array Loc	Data Bank Value	Location Ref: Variable Name	Location Ref: Size	Description
88	1.333	DBLØ(10)	-	K_{SK}, factor for skin pads, bulkhead attach
89	1.750	DBLØ(11)	-	K_{LT}, factor for skin pad width, bulkhead attach
(90-97)	-	(DSPLI)	(8)	Subarray DSPLI, blank common reference = D(1490)
90	0.500	DSPLI(1)	-	D_{bolt}, chordwise splice fastener diameter, in.
91	2.5	DSPLI(2)	-	K_D bolt, fastener spacing factor, number of bolt diameter, chordwise splice
92	1.0	DSPLI(3)	-	$K_{T\ max}$, tension cutoff stress for chordwise splice: ≤2.0 = fraction of F_{TU}; >2.0 = $F_{T\ max}$ allowable, psi
93	1.5	DSPLI(4)	-	$K_{BR\ max}$, bearing cutoff stress for chordwise splice: ≤2.0 = fraction of F_{BRU}; >2.0 = F_{BR} max allowable, psi
94	2.0	DSPLI(5)	-	N_S, type of splice: 1 = single shear; 2 = double shear
95	130,000.0	DSPLI(6)	-	$F_{S\ max}$, allowable shear stress for bolt, psi

TABLE 10. DC ARRAY, MISCELLANEOUS CONSTANTS (CONCL)

Array Loc	Data Bank Value	Location Ref Variable Name	Location Ref Size	Description
96	0.288	DSPLI(7)	-	ρ_{bolt}, density of bolt material (steel), lb/cu in.
97	4.5	DSPLI(8)	-	K_{LT}, factor for splice width
98-99	0.0	-	-	Not used
100	-	-	-	Do not use, used as DLED1(1)

TABLE 11. ARRAY REFERENCES, ARRAY D

Location	Name	Size	Reference	
			Overlay	Subroutine
1	D1	1	9,18	DLPVT, PIVØT
1	-	1	8	CASE, GCØMP, GEØMC, GEØMW, TBWDC, VSGEØM
			14	LETEI, LEWT, TEDEV, TEWT, TEWTI, WLETE
			15	CDL, FDIS, MISCIT, MISCNT, TBFWI1
			16	ABDW, ALØAD, CNSTC, GJCAL, GJSI, GJTT, MTLCW, MTLFW, SS2, VLØAD1, YBSET
			9	CSECW, DEADW, DWYBA, PIVØT, PRØG, PRTA, TBØPT, TEE, TEL, VLØAD1
			10	BHDJT, BØT, BØTC, CG3P, CNSTR, EIGJC, RTRIB, SECTD, SFSCH, SKWEB, SS, STBAR, STRG, STRGØ, STRIB, STRIL, STWEB, TSCH, WTCAL
			18	ACLØAD, ACNSTR, ACPRØG, ACPRTA, ACWMS, ACWRBS, ASTIFF, ATBØPT, AVLØAD, BHDJT, CSECW, DEADW, DWYBA, PIVØT, RTRIB, TEE, TEL, WTCAL
			17	TBFWI, WFLDD, WØDATA, WVFDD
2	D2	1	9,18	DLPVT, PIVØT
2	-	1	8	ABØXC, CASE, GCØMP, GEØMC, GEØMW, TBWDC, VSGEØM
			14	GCNTL, LETEI, LEWT, TEDEV, TEWT, TEWTI, WLETE
			15	CDL, FDIS, MISCIT, MISCNT, TBFWI1
			16	ABDW, ALØAD, CNSTC, GJCAL, GJTT, MTFLW, YBSET
			9	CSECW, DEADW, DLPVT, PIVØT, PRTA, TBØPT, TEE, TEL

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
			10	BHDJT, BØT, CG3P, CNSTR, EIGJC, RTRIB, SECTD, SFSCH, STRG, STRIB, STRIL, STWEB, TSCH, VFCAL, WTCAL
			18	ACEIGJ, ACLØAD, ACNSTR, ACPRØG, ACPRTA, ACWMS, ASTIFF, ATBØPT, BHDJT, CKSFDH, CSECW, DEADW, DLPVT, PIVØT, RTRIB, TEE, TEL, WEIGH1, WEIGH2, WTCAL
			17	TBFWI, WØDATA, WVFDD
3	D3	1	9,18	PIVØT
3	-	1	8	GEØMW, TBWDC
			14	LETEI, LEWT, TEDEV, TEWTI
			15	FDIS, MISCIT, MISCNT
			16	ALØAD, CNSTC, CJCAL
			9	DEADW, TBØPT, TEE, TEL
			10	BØT, BØTC, SECTD, STBAR
			18	ACNSTR, ATBØPT, DEADW, TEE TEL
			17	WØDATA, WVFDD
4	D4	1	9,18	PIVØT
4	-	1	8	GEØMW, TBWDC, VSGEØM
			14	TEDEV, TEWTI
			15	TBFWI1
			16	MTLFW
			9	PIVØT, TBØPT, TEE, TEL
			10	BHDJT, CG3P, EIGJC, SFSCH, STRIL, TSCH
			18	ACEIGJ, ACNSTR, ASTIFF, BHDJT, PIVØT, TEE, TEL
			17	TBFWI, WVFDD
5	-	1	14	LEWT, TEWT, TEWTI
			9	TBØPT
			10	STWEB
6	-	1	8	GCØMP, GEØMW, VSGEØM
			14	TEWTI
			9	TBØPT
7	-	1	9	PRØG, TBØPT

Location	Name	Size	Reference	
			Overlay	Subroutine
8	-	1	8	ABØXC, DMAX, GEØMC, GEØMW, TBWDC
9	-	1	-	-
10	-	1	8	TBWDC
			14	LEWT, TEWT
			15	CDL, FDIS
			9	TBØPT, TEE
			10	BØT, TSCH
			18	TEE
			17	WFLDD
11	-	1	8	TBWDC
12	-	1	8	GCØMP
			14	LETEI
			15	MISCIT, MISCNT, TBFWI1
			16	ALØAD, CNSTC, GJTT
			9	TEE
			10	STBAR, STRIB, STRIL
			18	ASTIFF, TEE
			17	TBFWI
13	-	1	-	-
14	-	1	10	EIGJC
15	PI	1	16	CNSTC
			9	PIVØT
			10	SECTD, STRIB, STRIL
			18	PIVØT, TEMPC
			17	WVFDD
15	-	1	9,18	PIVØT, TEE
16	-	1	8	GCØMP, GEØMW, PRTG, VSGEØM
			9,18	PIVØT, TEE, TEL
			17	WFLDD, WVFLD
17	C144	1	16	GJTT
17	-	1	8	GCØMP, GEØMW, TBWDC, VSGEØM
			14	GCNTL, LEWT, TEWTI
			15	MISCNT
			16	ALØAD, CNSTC
18	-	1	-	-
19	-	1	8	TBWDC
			14	GCNTL, LEWT, TEWTI
			16	ALØAD, YBSET

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
			9	CSECW, PIVØT
			10	BHDJT, CG3P, RTRIB, STRG, STRIB, STRIL
			18	ACWMS, ACWRBS, BHDJT, CSECW PIVØT, RTRIB
			17	WVFDD
20	-	1	10	EIGJC
21	-	1	14	LEWT, TEWTI
			16	GJSI, WDDATA
			9,18	PIVØT, TEE, TEL
22	-	1	17	WVFDD
23	-	1	10	STBAR, STRIB
24	DKMIR	1	18	ACNSTR, WEIGH1, WEIGH2
24	-	1	9,18	CSECW
			10	STBAR, STRIB
25	-	1	10	STRIB
26	-	1	-	-
27	-	1	10	BHDJT, STBAR
			18	BHDJT
28	-	1	10	STBAR
29	-	1	10	STBAR
30	-	1	10	STBAR
31	-	1	10	TSCH
32	-	1	10	TSCH
33	-	1	10	TSCH
34	-	1	10	TSCH
35	-	1	10	TSCH
36	-	1	10	BØT
37	-	1	10	SFSCH
38	-	1	10	SFSCH
39	-	1	10	SFSCH
40	-	1	10,18	RTRIB
41	-	1	16	SS2
			10	SS
42	-	1	16	SS2
			10	SS
43	-	1	16	SS2
			10	SS
44	-	1	16	SS2
			10	SS

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
45	-	1	16	SS2
			10	SS
46	-	1	16	SS2
			10	SS
47	-	1	-	-
48	-	1	-	-
49	-	1	-	-
50	-	1	14	TEWTI
		1	10	STRG, VFCAL
51	-	1	14	LEWT, TEWTI
			16	CNSTC, WDDATA
52	-	1	14	LEWT, TEWTI
53	-	1	-	-
54	-	1	10,18	BHDJT
55	-	1	-	-
56	-	1	10,18	BHDJT
57	-	1	10,18	BHDJT
58-63	DSPLØ	6	10,18	BHDJT
64	-	1	10	BØT, SFSCH, STRIB, TSCH
65	-	1	16	CNSTC, CNSTR
			10	CNSTR
66	-	1	16	CNSTC
67	-	1	16	CNSTC
68	-	1	16	CNSTC
69	DKMRR	1	10,18	RTRIB
70	-	1	16	CNSTC
71	-	1	16	CNSTC
72	-	1	16	CNSTC
73	-	1	8	CASE
74	CKNXI	1	10	CNSTR
74	-	1	16	CNSTC
75	-	1	-	-
76	-	1	-	-
77	-	1	-	-
78		1	-	-
79	DLFLD	1	15	FDIS
80-82	TØGW	3	8	CASE
			9	PIVØT, PRØG, PRTH
			10	PRTB, PRTC
			18	ACPRØG, PIVØT, PRTB, PRTC, PRTH

Location	Name	Size	Reference	
			Overlay	Subroutine
			17	PRTD
81	-	1	8	CCNTL
83	-	1	-	-
84	-	1	-	-
85	PNZ	1	16	ALØAD
85-86	DPNZ	2	8	CASE
85	-	1	8	CCNTL
86	ZNZ	1	16	ALØAD
86	-	1	8	CCNTL
87	QVL	1	8	CASE
			14	LEWT, TEDEV, TEWT
			15	MISCNT
87	-	1	8	CCNTL
88	TØGWØ	1	8	CASE
			18	ACLØAD
88	-	1	8	CCNTL
89-92	TØFL	4	8	CASE
89	-	1	8	CCNTL
91	-	1	8	CCNTL
93	DFUEL	1	8	CASE
93	-	1	8	CCNTL
94-97	DLFL	4	8	CASE
			16	ABDW
94	-	1	8	CCNTL
96	-	1	8	CCNTL
98-101	DLUL	4	8	CASE
98	-	1	8	CCNTL
100	-	1	8	CCNTL
102-105	DGWI	4	8	CASE
102-104	DGW	3	9	PIVØT, PRØG, PRTA, PRTH
			10	PRTB, PRTC
			18	ACPRØG, ACPTRA, PIVØT, PRTB, PRTC, PRTH
			17	PRTD
105	DGWØ	1	8	CASE
			14	LEWT
			15	FDIS
			16	ABDW, ALØAD
			19	PRØG

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference: Overlay	Reference: Subroutine
			18	ACLØAD, ACPRØG
106	-	1	-	-
107	-	1	-	-
108	-	1	-	-
109	-	1	-	-
110	DWID	1	16	ABDW
110	-	1	8	CCNTL
111	-	1	-	-
112	-	1	-	-
113	DKDW3	1	9,18	DWYBA
114	DKYB1	1	9,18	DWYBA
115	DYBKS	1	16	YBSET
116	DYBKP	1	16	YBSET
117	DYBDP	1	16	YBSET
118	-	1	-	-
119	-	1	-	-
120	-	1	-	-
121	-	1	-	-
122	ULTLF	1	8	CASE
			15	CDL
			16	MTLCW, VLØAD1
			9	DWYBA, VLØAD
			18	AVLØAD, DWYBA
123	-	1	-	-
124	AC	1	9, 18	PIVØT
125-127	TBIBX	3	8	ABØXC, GEØMW
125	FSLØC	1	9,18	PIVØT
126	RSLØC	1	9,18	PIVØT
127	-	1	8	CCNTL
128	TBYIB	1	8	GEØMW
129	TBYØB	1	8	GEØMW
130-134	-	5	-	-
135-137	TBØBX	3	8	GEØMW
138	SWPPC	1	8	GEØMW, GCØMP
138	-	1	8	CCNTL
139	YØBD	1	8	TBWDC
140	-	1	-	-
141	YIBTC	1	8	GEØMW
142	YØBTC	1	8	GEØMW, TBWDC

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference: Overlay	Reference: Subroutine
143	AFID	1	8	ABØXC, DMAX, GEØMC, GEØMW, TBWDC
144	DKDWØ	1	15	FDIS
144	-	1	8	CCNTL
145-148	YAF	4	8	GEØMC
149-152	AFN	4	8	GEØMC
153	AFCC	1	8	ABØXC
154	-	1	-	-
155	-	1	-	-
156	DP1	1	9,18	PIVØT
157	DP2	1	9,18	PIVØT
158	-	1	-	-
159-166	DFLD1	8	16	ABDW
			18	ACLØAD
167-174	DCDL1	8	16	ABDW
			9	PRØG
			18	ACLØAD, ACPRØG
175	WYREF	1	8	GEØMW
175	-	1	8	CCNTL
176	WXREF	1	8	GEØMW
176	-	1	8	CCNTL
177	WCREF	1	8	GEØMW
177	-	1	8	CCNTL
178	WEREF	1	8	GEØMW
178	-	1	8	CCNTL
179-185	-	7	-	-
186	DEPTH	1	9,18	PIVØT
187	-	1	-	-
188	-	1	-	-
189	PERFTU	1	9,18	PIVØT, TEL
190	RATFSU	1	9,18	PIVØT
191	RHØPIN	1	9,18	PIVØT
192	CKA	1	9,18	PIVØT, TEE, TEL
193	CKB	1	9,18	PIVØT, TEE, TEL
194	CKC	1	9,18	PIVØT, TEE, TEL
195	FBR	1	9,18	PIVØT
196	DPVMN	1	16	MTLCW
196	-	1	8	CCNTL
197	DPVMT	1	16	MTLCW

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
197	-	1	8	CCNTL
198	ØDPVT	1	9,18	PIVØT
199	DN	1	9,18	PIVØT, TEE
199	-	1	8	CCNTL
200	DYPVT	1	8	GCØMP, PRTG, VSGEØM
			16	GJCAL, MTLCW
			9	PIVØT, TBØPT
			18	ATBØPT, PIVØT
			17	PRTD
200	-	1	8	CCNTL
201	DXPVT	1	8	VSGEØM
201	XPVT	1	9,18	PIVØT
201	-	1	8	CCNTL
202	THPFWD	1	9,18	PIVØT, TEL
202	-	1	8	CCNTL
203	THPAFT	1	9,18	PIVØT
203	-	1	8	CCNTL
204	TTDIH	1	17	WØDATA
204	-	1	8	CCNTL
205	SLDID	1	16	ALØAD
			18	ACLØAD
206-219	DFL	14	15	FDIS
206-219	-	14	8	CCNTL
220-231	CAL1	12	16	ADØAD
232	DEXPV	1	16	ALØAD
233	DCPKL	1	16	ALØAD
234	DKVL	1	9	PRØG
			18	ACPRØG
235	ALGS	1	16	ALØAD
236	ALGAR	1	16	ALØAD
237	ALGTR	1	16	ALØAD
238	ALGB1	1	16	ALØAD
239	ALREF	1	16	ALØAD
239	-	1	8	CCNTL
240	WAREA	1	8	GCØMP, GEØMW

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
			14	LEWT
			16	ALØAD
240	-	1	8	CCNTL
241	WAR	1	8	GCØMP, GEØMW
241	-	1	8	CCNTL
242	WSWP	1	8	GCØMP, GEØMW
242	-	1	8	CCNTL
243	TCIB	1	8	GEØMW
243	WTØC	1	9,18	PIVØT
243	-	1	8	CCNTL
244	WTR	1	8	GCØMP, GEØMW
			9,18	PIVØT
244	-	1	8	CCNTL
245	WSIG	1	8	GEØMW
			9,18	PIVØT
245	-	1	8	CCNTL
246	DSFUS	1	8	GEØMW
246	CCSPN	1	9,18	CSECW
246	-	1	8	CCNTL
247	WDIH	1	8	GEØMW
247	-	1	8	CCNTL
248	ZDIH	1	8	GEØMW
248	-	1	8	CCNTL
249	-	1	8	CCNTL
250	DLWG	1	8	CASE
251	VFID	1	16	GJCAL
			18	ACPRØG, ACPRTA, ASTIFF
252	VFK	1	8	GEØMW
253	VFQ	1	8	GEØMW
253	-	1	8	CCNTL
254	VFG	1	8	GEØMW
254	-	1	8	CCNTL
255	DALV	1	16	ALØAD
256	DALCP	1	16	ALØAD
257	DCPCD	1	16	ALØAD
258	DMN	1	16	MTLCW
259	DMTI	1	8	GEØMW, VSGEØM
			16	MTLCW
			18	ACLØAD

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
259	-	1	8	CCNTL
260-270	PNZM	11	16	ALØAD
271	DINID	1	18	ACPRØG, ACPRTA
			17	WØDATA
272-273	DFXF	2	17	WFLDD
274-275	DFXC	2	16	CDL
			17	WFLDD
276-277	DVFF	2	17	WVFDD
278-279	DVFC	2	17	WVFDD
280	DINTP	1	17	PINTØ, WFLDD
281	DTMPB	1	18	ACPRØG
282	DTMPGJ	1	8	GEØMW
282	-	1	8	CCNTL
283	DTMPFL	1	18	ACPRØG
284	DTMPFØ	1	18	ACPRØG
285-286	UPNZ	2	8	CASE
285	UPNZ	1	15	CDL
			16	VLØAD1
			9	DWYBA, VLØAD
			18	DWYBA
285	ULTNZ	1	14	LEWT
286	UNNZ	1	16	VLØAD1
			9	VLØAD
			18	AVLØAD
287	DQVL	1	8	CASE
			18	AVLØAD
288	-	1	-	-
289	DHVID	1	8	CASE
			14	LEWT, TEDEV, TEWT
289	VTID	1	16	ABDW, GJCAL, MTLCW, MTLPW, YBSET
			10	SECTD
			18	ACLØAD
			17	PRTD, WØDATA
289	-	1	8	CCNTL
			16	VLØAD1
			9	VLØAD
290	VH1	1	17	WFLDD
291	VH2	1	17	WFLDD

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
292	DFFL	1	17	WFLDD
293	DGFL	1	17	WFLDD
294	-	1	-	-
295	DGWVF	1	17	WVFDD
296	CGFS	1	17	WVFDD
297	DGWIY	1	17	WVFDD
298	DGWIX	1	17	WVFDD
299	WWPC	1	17	WVFDD
300	WWCY	1	17	WVFDD
301	WWCX	1	17	WVFDD
302	WWCIY	1	17	WVFDD
303	WWCIX	1	17	WVFDD
304	VFMN	1	17	WVFDD
305	VFALT	1	17	WVFDD
306	VFRHØ	1	17	WVFDD
307	VFDE	1	17	WVFDD
308	VFDG	1	17	WVFDD
309	VFKSP	1	17	WVFDD
310	DTT	1	16	GJTT
310	-	1	8	CCNTL
311	-	1	-	-
312	CJFAC	1	8	GEØMW, VSGEØM
313	GJYI	1	8	GEØMW, VSGEØM
314	GJKI	1	16	GJCAL
315	GJYØ	1	8	GEØMW, VSGEØM
316	GJKØ	1	16	GJCAL
317	ART	1	16	GJCAL
318	ATP	1	16	GJCAL
319	-	1	-	-
320	DLLMDA	1	8	GEØMW, PRTG, VSGEØM
320	-	1	8	CCNTL
321	QLMDA	1	8	VSGEØM
321	-	1	8	CCNTL
322	GLMDA	1	8	VSGEØM
322	-	1	8	CCNTL
323	TLMDA	1	8	VSGEØM
323	-	1	8	CCNTL
324	DKLMDA	1	8	VSGEØM

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
325-334	-	10	-	-
335	TTVFT	1	16	GJCAL
335	-	1	8	CCNTL
336	AMACH	1	16	GJTT
337	TTVFQ	1	16	GJTT
	Q	1	16	GJTT
337	-	1	8	CCNTL
338	TTVFG	1	16	GJCAL
338	-	1	8	CCNTL
339	TTJFC	1	16	GJTT
339	-	1	8	CCNTL
340	GJS	1	8	GEØMW, VSGEØM
341	GJAR	1	8	GEØMW
342	GJTR	1	8	GEØMW
343	GJB1	1	8	GEØMW, VSGEØM
344	GJTC	1	8	GEØMW
345	GJSIG	1	8	GEØMW
346-356	DGJI	11	16	GJCAL
357	TTID	1	16	GJCAL
358	-	1	8	CCNTL
359	-	1	8	CCNTL
360	YIHT	1	16	GJTT
360	-	1	8	CCNTL
361	STRFN	1	16	CNSTC
			10	SECTD, SFSCH, STBAR, STRG, STRGØ, STRIL, TSCH
362	CKSK	1	16	CNSTC
363	CKSTI	1	16	CNSTC
364	CKSTZ	1	16	CNSTC
			10	STRIL
365	SKKMN	1	16	CNSTC
366	SKKMX	1	16	CNSTC
367	CØNTC	1	16	CNSTC
			10	SECTD
368	DVFID	1	16	CNSTC
369	DWNØ	1	9	PRØG
			18	ACPRØG
370	SKMN	1	16	CNSTC, YBSET

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
			10	BHDJT, CNSTR, SECTD, TSCH, WTCAL
			18	BHDST, WTCAL
371	STRMN	1	16	YBSET
			10	SECTD, SFSCH, STRG, STRGØ, TSCH
372	RBMG	1	10	STRIB
373-374	SWBMG	2	10	STWEB
375	STLMN	1	10	CNSTR, STBAR, TSCH
			18	ATBØPT
375	-	1	9	PRØG, TBØPT
			10	CNSTR
376	STLMX	1	10	CNSTR, STBAR, TSCH
			18	ATBØPT
376	-	1	9	PRØG, TBØPT
			10	CNSTR
377	HSTMN	1	15	FDIS
			16	CNSTC, YBSET
			10	CNSTR, SECTD, STRG, TSCH
			18	ATBØPT
377	-	1	9	PRØG
378	HSTMX	1	10	CNSTR, SECTD, STRG, TSCH
			18	ATBØPT
378	-	1	9	PRØG
379	STFMX	1	16	YBSET
			10	SECTD, STRG, STRGØ
			18	ATBØPT
380	BMIN	1	16	CNSTC, YBSET
			10	CNSTR, SECTD
			18	ATBØPT
380	-	1	9	PRØG, TBØPT
			10	CNSTR
381	BMAX	1	16	CNSTC, YBSET
			10	SECTD
			18	ATBØPT
381	-	1	9	PRØG, TBØPT
			10	CNSTR
382	SNMIN	1	16	CNSTC, YBSET

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference: Overlay	Reference: Subroutine
			10	SECTD
			18	ATBØPT
382	-	1	9	PRØG, TBØPT
			10	CNSTR
383	STRCN	1	16	CNSTC
			18	ATBØPT
383	-	1	10	PRØG
384	STFMN	1	16	CNSTC, YBSET
			10	SECTD, STRG, STRGØ TSCH
			18	ATBØPT
385	SDCMX	1	16	CNSTC
386	SDTMX	1	16	CNSTC, MTLCW
387	SDSMX	1	16	CNSTC
388	SDFCL	1	16	CNSTC
389	ELWR	1	16	CNSTC
390	RHØL	1	16	CNSTC
391	EFLWR	1	16	CNSTC
392	CKNXL	1	16	ALØAD, CNSTC
			10	CNSTR
393	CØLID	1	10	STRIL
394	SKMNL	1	16	CNSTC, YBSET
			10	CNSTR, SECTD
395	TKMNL	1	16	CNSTC
			10	CNSTR, SECTD
396	DRVT	1	10	STBAR
397	TRVT	1	10	STBAR, STRIB
398	SDFTU	1	16	CNSTC
399	SNMAX	1	18	ATBØPT
400	CFRIB	1	10	STRIB
			18	ACNSTR, ACWSTR, WEIGH1, WEIGH2
401	CKLR	1	16	CNSTC
402	CKGR	1	16	CNSTC
403	CØRMN	1	10	SRRIB
404	CØRMX	1	10	SRRIB
405	RBLCP	1	10	STRIB
406	DELTW	1	10	STRIB
407	CFIX	1	10	STRIL
			18	ACWSTR

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
408	DCCSH	1	16	CNSTC
409	DCCSF	1	16	CNSTC
410-411	SWKMS	2	10	STWEB, WTCAL, WTPIN
			18	ACNSTR, WTCAL, WTPIN, WEIGH1, WEIGH2
412-413	SFSRS	2	16	CNSTC
414-415	SWRHØ	2	16	CNSTC
416-417	SWBE	2	16	CNSTC
418-419	SWWST	2	10	STWEB
420-421	SWBST	2	10	STWEB
422	DELTW	1	10	STWEB
423-424	SWBCP	2	10	CNSTR, STWEB
			18	ACNSTR, ACWMS, ACWRBS, ASTIFF, WEIGH1, WEIGH2
425-426	SWKST	2	10	STWEB
427-428	SWBCF	2	18	ACNSTR, WEIGH1, WEIGH2
429	ACKNP	1	18	ATBØPT
430	ACID	1	10	PRTB, PRTC
			18	ACNSTR, ACPRTA, ASTIFF, ATBØPT, PRTB, PRTC
			17	WVFDD
431	ACCVID	1	18	ACPRTA, ATBØPT, TEMPC
432	ACVSTU	1	18	ATBØPT
433	ACVSTL	1	13	ATBØPT
434	ACFDHC	1	18	ACWFDH
435	ACSPID	1	18	ATBØPT
436	ACFSID	1	18	ATBØPT
437	ACRSID	1	18	ATBØPT
438	ACSSID	1	18	ACWMS, ACWRBS, ATBØPT
439	-	1	-	-
440	DSKLMU	1	18	ATBØPT
441	DSKLML	1	18	ATBØPT
442	DSTLMU	1	18	ATBØPT
443	DSTLML	1	18	ATBØPT
444	DBØTEP	1	18	ACSTRG
445	DPØAEP	1	18	ACMRSK
446	-	1	-	-
447	-	1	-	-

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
448	-	1	-	-
449	-	1	-	-
450	EBASC	1	16	CNSTC
451	GBASC	1	16	CNSTC
452	GLWRT	1	16	CNSTC
453-454	GFSRT	2	16	CNSTC
455	STRSK	1	10	BØT, SFSCH, STRG, TSCH
456	STRRØ	1	10	BØTC, SFSCH, STRG
457	ACKIC	1	18	ATBØPT
458	ACPNLI	1	18	ATBØPT
459	ACPNLF	1	18	ATBØPT
460	ACPNLR	1	18	ATBØPT
461	CNSID	1	16	CNSTC,YBSET
			9	TBØPT
			10	BHDJT, BØT, BØTC, RTRIB, SECTD, STBAR, STRG, STRIB, STRIL, TSCH, WTCAL
			18	BHDJT, RTRIB, WTCAL
			17	PRTD
462-469	DSPR	8	10,18	BHDJT, RTRIB
462	DTC	1	16	CNSTC, YBSET
			10	BØT, SECTD, SFSCH, STRIL
			18	ATBØPT
463	DCRHØ	1	16	CNSTC
464	DBRHØ	1	16	CNSTC
			18	ACNSTR, ACWSTR, WEIGH1, WEIGH2
465	DINS	1	16	CNSTC, YBSET
			18	ATBØPT
466	DTCL	1	16	CNSTC, YBSET
			10	SECTD
			18	ATBØPT
467	DINSL	1	16	CNSTC, YBSET
			18	ATBØPT
469	DINRHØ	1	18	ATBØPT
470	DPFRHØ	1	18	ATBØPT
471	-	1	-	-
472	-	1	-	-
473	-	1	-	-

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
474	-	1	-	-
475	-	1	-	-
476	-	1	-	-
477	-	1	-	-
478	-	1	-	-
479	-	1	-	-
480	CSWD	1	8	TBWDC
			9,18	CSECW
			17	WØDATA
481	CSDEL	1	9,18	CSECW, DLPVT
481-510	DELCS	30	17	PRTD
482-509	DELCS	28	9,18	CSECW
482-505	DLCS	24	9	DLPVT, TBØPT
			18	ATBØPT, DLPVT
502-505	DLCR	4	9, 18	CSECW
506	CSFS	1	8	TBWDC
520	DELST	1	10,18	RTRIB
521-528	DSTIE	8	16	CNSTC
			10,18	RTRIB
529	-	1	-	-
530-536	DELPV	7	9,18	DLPVT
			17	PRTD
537-549	-	13	-	-
550-573	DKS	24	10	SKWEB, STWEB
574-578	DBKP	5	10	TSCH
			18	ATBØPT
575	-	1	10	PRTBK
576	-	1	10	PRTBK
577	-	1	10	PRTBK
578	-	1	10	PRTBK
579	DKMPLI	1	18	ATBØPT
580-594	CFMTL	5,3	18	TEMPC
595	CFBMU	1	18	TEMPC
596	CFBCY	1	18	TEMPC
597	DFSRHØ	1	18	ATBØPT
598	DSTRC5	1	18	ACMRSK
599	DSTRC6	1	18	ACMRSK

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
600-629	DLTB	30	8	CASE
			16	CNSTC
601	DLLE	1	8	CASE
602	DLTE	1	8	CASE
603	DLMS	1	8	CASE
630-638	-	9	-	-
639-649	DKFCU	11	10	CNSTR
650-660	DBLHD	11	10	CNSTR, SECTD
			18	ACNSTR
661-671	DJØNT	11	10	CNSTR, SECTD
			18	ACNSTR
672-685	-	14	-	-
686	DLDID	1	8	CASE
687-697	VPNZ	11	16	ALØAD
698-708	VNNZ	11	16	ALØAD
709-719	ZNNM	11	16	ALØAD
720	-	1	-	-
721-731	DCSKU	11	10	CNSTR
732-742	DCSKL	11	10	CNSTR
743-753	DTSKU	11	10	CNSTR
754-764	DTSKL	11	10	CNSTR
765-775	DCBST	11	9	PRØG, TBØPT
			10	CNSTR
			18	ACWMS, ACWRBS
776-786	DCNØS	11	9	PRØG, TBØPT
			10	CNSTR
			18	ACWMS, ACWRBS
787-797	DCLST	11	10	CNSTR
798-808	DCHST	11	10	CNSTR
809-819	DLCFS	11	10	CNSTR
820-830	DLCRS	11	10	CNSTR
831-841	DKNXL	11	10	CNSTR
842-852	DVFS	11	16	VLØAD1
			9	VLØAD
			18	ACWMS, ACWRBS, AVLØAD
853-863	DVRS	11	16	VLØAD1
			9	VLØAD
			18	ACWMS, ACWRBS, AVLØAD
864	DYID	1	8	TBWDC

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
864	-	1	8	CCNTL
865-875	DYS	11	8	TBWDC
865-875	-	11	8	CCNTL
876-886	DTBW	11	8	TBWDC
887-897	DTBD	11	8	TBWDC
898-908	DFS	11	8	TBWDC
909-919	DRS	11	8	TBWDC
920-930	-	11	-	-
931-941	DNXU	11	16	YBSET
			10	CNSTR, EIGJC, SECTD, SFSCH
			18	ACWMS, ACWRBS
942-952	DNXL	11	10	CNSTR, EIGJC, SECTD, SFSCH
			18	ACWMS, ACWRBS
953-963	-	11	-	-
964-974	-	11	-	-
975-985	-	11	-	-
986-996	-	11	-	-
997-1007	DYBU	11	16	YBSET
1008-1018	DKFTL	11	10	CNSTR
1019-1029	PNET	11	16	ALØAD
1030-1040	ZNNT	11	16	ALØAD
1041-1051	DYBL	11	16	YBSET
1052-1087	-	36	-	-
1088-1119	DTBX	32	8	CASE
			10,18	WTCAL
1120	DTBZI	1	15	FDIS
1121-1142	DTBZ	22	15	FDIS
1143-1154	DINTI	12	14	LEWT, TEWT
			15	FDIS
1155-1163	ENP	9	18	ACEIGJ, ACMRSK, ACNSTR, ACPRØG, ACSTRG, ACWFDH, ACWMS, ACWRBS, ACWSTR, ASTIFF, ATBØPT, CKSFDH, CKSTAB, TEMPC, WEIGH1, WEIGH2
1164-1169	ENH	6	18	ACNSTR, ACPRTA, ACWFDH, ACWMS, ATBØPT, CKSFDH, CKSTAB, TEMPC
1165	CFBE	1	18	TEMPC
1166	CFBG	1	18	TEMPC

TABLE 11. ARRAY REFERENCES, ARRAY D (CONT)

Location	Name	Size	Reference: Overlay	Reference: Subroutine
1170-1204	TC	5,7	18	TEMPC
1205-1234	DLE	30	14	LEWT
1235-1279	DTE	45	14	TEWT
1280-1294	DCDL2	15	15	CDL
1280	-	1	8	CCNTL
1295-1300	-	6	-	-
1301-1322	DCNST3	22	9	PRØG
			18	ACPRØG
1323-1347	-	25	-	-
1348-1352	STFNH	5	18	ACSTRG, ACWSTR
1353-1357	STFNF	5	18	ACSTRG, ACWSTR
1358-1364	-	7	-	-
1365	DØPT	1	9	PRØG
1366	DØPTJ	1	9	TBØPT
1367-1370	DØP2	4	9	TBØPT
			18	ACWMS, ACWRBS
1371-1374	DØP3	4	9	TBØPT
			18	ACWMS, ACWRBS
1375-1386	-	12	-	-
1387-1397	-	12	-	-
1399	DØPTP	1	9	PRØG
1400	-	1	-	-
1401-1500	DC	100	-	DEFINED IN TABLE 10.
1470-1474	SLCFS	5	16	YBSET
			10	BHDJT, CNSTR, STWEB, WTCAL
			18	ACNSTR, ACWMS, ACWRBS, ASTIFF, BHDJT, WEIGH1, WEIGH2, WTCAL
1475-1478	DRIS	4	10	SECTD, SFSCH
1479-1489	DBLØ	11	10,18	BHDJT, RTRIB
1490-1497	DSPLI	8	16	CNSTC
			10,18	BHDJT
1498	-	1	-	-
1499	-	1	-	-
1500-1529	DLED1	30	14	LEWT
1530-1579	DLEDK	50	14	LEWT
1580-1609	DTED1	30	14	TEDEV
1610-1729	DTED2	120	14	TEDEV
1730-1744	DSPDK	15	14	TEDEV

TABLE 11. ARRAY REFERENCES, ARRAY D (CONCL)

Location	Name	Size	Reference	
			Overlay	Subroutine
1745-1764	DFLPK	20	14	TEDEV
1765-1794	DAILK	30	14	TEDEV
1795-1819	DFSP	25	14	TEDEV, TEWTI
1820-1854	DMWT	35	15	MISCNT
1820-1827	-	8	8	CCNTL
1855-1954	DCDL	100	15	CDL
			17	WVFDD
1855-1857	-	3	8	CCNTL
1860-1865	-	6	8	CCNTL
1867-1869	-	3	8	CCNTL
1872-1877	-	6	8	CCNTL
1879-1881	-	3	8	CCNTL
1884-1889	-	6	8	CCNTL
1891-1893	-	6	8	CCNTL
1896-1901	-	3	8	CCNTL
1903-1910	-	8	8	CCNTL
1915-1922	-	8	8	CCNTL
1927-1929	-	3	8	CCNTL
1932-1937	-	6	8	CCNTL
1955-1969	DTIP	15	15	MISCNT
1970-1984	DKDIN	15	14	LETEI
			15	FDIS, MISCIT, MISCNT
			17	WØDATA
1985-2007	DLE	23	8	GEØMC
2008-2030	DTE	23	8	GEØMC
2031-2052	DTC	22	8	GCØMP, GEØMC
2053-2060	-	8	-	-

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
AC	124	1					9		18	
ACCVID	431	1							18	
ACFDHC	434	1							18	
ACFSID	436	1							18	
ACID	430	1						10	18	17
ACKIC	457	1							18	
ACKNP	429	1							18	
ACPNLF	459	1							18	
ALPNLI	458	1							18	
ACPNLR	460	1							18	
ACRSID	437	1							18	
ACSPID	435	1							18	
ACSSID	438	1							18	
ACVSTL	433	1							18	
ACVSTU	432	1							18	
AFCC	153	1	8							
AFID	143	1	8							
AFN	149-152	4	8							
ALGAR	236	1				16				
ALGB1	238	1				16				
ALGS	235	1				16				
ALGTR	237	1				16				
ALREF	239	1				16				
AMACH	336	1				16				
ART	317	1				16				
ATIP	318	1				16				
BMAX	381	1				16		10	18	
BMIN	380	1				16		10	18	
CAL1	220-231	12				16				
CCSPN	246	1					9		18	
CFBE	1165	1							18	

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
CFBCY	596	1							18	
CFBG	1166	1							18	
CFBMU	595	1							18	
CFIX	407	1						10	18	
CFMTL	580-594	5,3							18	
CFRIB	400	1						10	18	
CGFS	296	1								17
CKA	192	1					9		18	
CKB	193	1					9		18	
CKC	194	1					9		18	
CKGR	402	1				16				
CKLR	401	1				16				
CKNXI	74	1						10		
CKNXL	392	1				16		10		
CKSK	362	1				16				
CKSTI	363	1				16				
CKSTZ	364	1				16				
CNSID	461	1				16	9	10	18	17
CØLID	393	1						10		
CØNTC	367	1				16		10		
CØRMN	403	1						10		
CØRMX	404	1						10		
CØS10	1438	1				16				
CSDEL	481	1					9		18	
CSFS	506	1	8							
CSWD	480	1	8				9		18	17
C144	17	1				16				
DALIK	1765-1794	14	14							
DALCP	256					16				
DALV	255					16				
DBKP	574-578	5						10	18	
DBLHD	650-666	11						10	18	
DBLØ	1479-1489	11						10	18	
DBØTEP	444	1							18	
DBRHØ	464	1				16			18	

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
DC	1401-1500	100	8	14	15	16	9	10	18	17
DCBST	765-775	11					9	10	18	
DCCSF	409	1				16				
DCCSH	408	1				16				
DCDL	1855-1954	100			15					17
DCDL1	167-174	8				16	9		18	
DCDL2	1280-1294	15			15					
DCHST	798-808	11						10		
DCLST	787-797	11						10		
DCNØS	776-786	11					9	10	18	
DCNST3	1301-1322	22					9		18	
DCPCD	257	1				16				
DCPKL	233	1				16				
DCRHØ	463	1				16				
DCSKL	732-742	11						10		
DCSKU	721-731	11						10		
DEFL	292	1								17
DELCS	581-510	30								17
DELCS	482-509	28					9		18	
DELPV	530-536	7					9		18	17
DELST	520	1						10	18	
DELTW	406	1						10		
DELTW	422	1						10		
DEPTH	186	1					9		18	
DEXPV	232	1				16				
DFL	206-219	14			15					
DFLD1	159-166	8				16			18	
DFLPK	1745-1764	20		14						
DFREIK	1404	1							18	
DFS	898-908	11	8							
DFSP	1795-1819	25		14						
DFSRHØ	597	1								
DFUEL	93	1	8						18	
DFXC	274-275	2				16				17
DFXF	272-273	2								17
DGFL	293	1								17
DGJI	346-356	11				16				
DGW	102-104	3					9	10	18	17
DGWI	102-105	4	8							
DGWØ	105	1	8	14	15	16	9		18	17

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
DGWIX	298	1								17
DGWIY	297	1								17
DGWVF	295	1								17
DHVID	289	1	8	14						
DINID	271	1							18	17
DINRAØ	469	1							18	
DINS	465	1				16			18	
DINSL	467	1				16			18	
DINTI	1143-1154	12		14	15					
DINTP	280	1								17
DJØNT	661-671	11						10	18	
DKDIN	1970-1984	15		14	15					17
DKDWØ	144	1			15					
DKDW3	113	1					9		18	
DKFCU	639-649	11						10		
DKFTL	1008-1018	11						10		
DKLMDA	324	1	8							
DKMIR	24	1							18	
DKMPLI	579	1							18	
DKNXL	831-841	11						10		
DKMRR	69	1						10	18	
DKS	550-573	24						10		
DKVL	234	1					9		18	
DKYB1	114	1					9		18	
DLCFS	809-819	11						10		
DLCR	502-505	4					9		18	
DLCRS	820-830	11						10		
DLCS	482-505	24					9	18		
DLDID	686	1	8							
DLE	1205-1234	30		14						
DLE	1985-2007	23	8							
DLEDK	1530-1579	50		14						
DLED1	1500-1529	30		14						
DLFL	94-97	4	8			16				
DLFLD	79	1			15					
DLLE	601	1	8							
DLLMDA	320	1	8							
DLMS	603	1	8							
DLTB	600	1	8							
DLTE	602	1	8							

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
DLUL	98-101	4	8							
DLWG	250	1	8							
DMN	259	1				16				
DMTI	259	1	8			16			18	
DMWT	1820-1854	35	8		15					
DN	199	1					9		18	
DNXC	942-952	11						10	18	
DNXU	931-941	11				16		10	18	
DØPT	1365	1					9			
DØPTJ	1366	1					9			
DØPTP	1399	1					9			
DØP2	1367-1370	4					9		18	
DØP3	1371-1374	4					9		18	
DFPRHØ	470	1							18	
DPNZ	85-86	2	8							
DPØAEP	445	1							18	
DPVMN	196	1				16				
DPVMT	197	1				16				
DP1	156	1					9		18	
DP2	157	1					9		18	
DQVL	287	1	8						18	
DRS	909-919	11	8							
DRIS	1475-1478	4						10		
DRVT	396	1						10		
DSFUS	246	1	8							
DSKLML	440								18	
DSKLMU	441	1							18	
DSKDK	1730-1744	15		14						
DSPLI	1490-1497	8				16		10	18	
DSPLØ	58-63	6						10	18	
DSPR	462-469	8						10	18	
DSTIE	521-528	8				16		10	18	
DSTLML	443	1							18	
DSTLMU	442	1							18	
DSTRC5	598	1							18	
DSTRC6	599	1							18	
DTBD	887-897	11	8							
DTBW	876-886	11	8							
DTBX	1088-1119	32	8					10	18	
DTBZ	1121-1142	22			15					

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
DTBZI	1120	1			15					
DTC	462	1				16		10	18	
DTC	2031-2052	22	8							
DTCL	466	1				16		10	18	
DTE	1235-1279	45		14						
DTE	2008-2030	23	8							
DTED1	1580-1609	30		14						
DTED2	1610-1729	120		14						
DTIP	1955-1969	15			15					
DTMPB	281	1							18	
DTMPFL	283	1							18	
DTMPFØ	284	1							18	
DTMPGJ	282	1	8							
DTSKL	754-764	11						10		
DTSKU	743-753	11						10		
DTT	310	1				16				
DVFC	278-279	2								17
DVFID	368	1				16				
DVFF	276-277	2								17
DVFS	842-852	11				16	9		18	
DVRS	853-863	11				16	9		18	
DWID	110	1				16				
DWNØ	369	1					9		18	
DXPVT	201	1	8							
DYBDP	117	1				16				
DYBKP	116	1				16				
DYBKS	115	1				16				
DYBL	1041-1051	11				16				
DYBU	997-1007	11				16				
DYID	864	1	8							
DYPVT	200	1	8			16	9		18	17
DYS	865-875	1	8							
D1	1	1					9		18	
D2	2	1					9		18	
D3	3	1					9		18	
D4	4	1					9		18	

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
EBASC	450	1				16				
EFLWR	391	1				16				
ELWR	389	1				16				
ENH	1155-1163	9							18	
ENP	1164-1169	6							18	
FBR	195	1					9		18	
FSLØC	125	1					9		18	
GBASC	451	1				16				
GFSRT	453-454	2				16				
GSAR	341	1	8							
GJB1	343	1	8							
GJFAC	312	1	8							
GJKI	314	1				16				
GJKØ	316	1				16				
GJS	340	1	8							
GJSIC	345	1	8							
GJTC	344	1	8							
GJTR	342	1	8							
GJYI	313	1	8							
GJYØ	315	1	8							
GLMDA	322	1	8							
GLWRT	452	1				16				
GOFPS	1443	1				16				
HSTMN	377	1			15	16		10	18	
HSTMX	378	1						10	18	

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
ØDPVT	198	1					9		18	
PERFTU	189	1					9		18	
PI	15	1				16	9	10	18	17
PNZ	85	1				16				
PNZM	260-270	11				16				
PNZT	1019-1029	11				16				
PT4	1436	1				16				
PT7	1437	1				16				
PT8	1438	1				16				
Q	337	1				16				
QLMDA	321	1	8							
QVL	87	1	8	14	15					
Q0	1433	1				16				
RATFSU	190	1					9		18	
RBLCP	405	1						10		
RBMG	372	1						10		
RHØL	390	1				16				
RHØPIN	191	1					9		18	
RSLØC	126	1					9		18	

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References 8	14	15	16	9	10	18	17
SDCMX	385	1				16				
SDFCL	388	1				16				
SDFTU	398	1				16				
SDSMX	387	1				16				
SDTMX	386	1				16				
SFSRS	412-413	2				16				
SIN10	1439	1				16				
SKKMN	365	1				16				
SKKMX	366	1				16				
SKMN	370	1				16		10	18	
SKMNL	394	1				16		10		
SLCFS	1470-1474	5				16		10	18	
SLDID	205	1				16			18	
SNMAX	399	1							18	
SNMIN	382	1				16		10	18	
STFMN	384	1				16		10	18	
STFMX	379	1				16		10	18	
STFNF	1353-1357	5							18	
STFNH	1348-1352	5							18	
STLMN	375	1						10	18	
STLMX	376	1						10	18	
STRCN	383	1				16			18	
STRFN	361	1				16		10		
STRMN	371	1				16				
STRRØ	456	1						10		
STRSK	455	1						10		
SWBCF	427-429	2							18	
SWBCP	423-424	2						10	18	
SWBE	416-417	2				16				
SWBMG	373-374	2						10		
SWBST	420-421	2						10		
SWKMS	410-411	2						10	18	
SWKST	425-426	2						10		

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
SWPPC	138	1	8							
SWRHØ	414-415	2				16				
SWWST	418-419	2						10		
TBIBX	125-127	3	8							
TBØBX	135-137	3	8							
TBYIB	128	2	8							
TBYØB	129	2	8							
TC	1170-1204	5,7							18	
TCIB	243	1	8							
THPAFT	203	1					9		18	
THPFWD	202	1					9		18	
TKMNL	395	1				16		10		
TLMDA	323	1	8							
TØFL	89-92	4	8							
TØGW	80-82	3	8				9	10	18	17
TØGWØ	88	1	8						18	
TRVT	397	1						10		
TTID	357	1				16				
TTIDH	204	1								17
TTJFC	339	1				16				
TTVFG	338	1				16				
TTVFQ	337	1				16				
TTVFT	335	1				16				
ULTLF	122	1	8		15	16	9		18	
ULTNZ	285	1		14						
UNNZ	286	1				16	9		18	
UPNZ	285	1			15	16	9		18	
UPNZ	285-286	2	8							

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONT)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
VFALT	305	1								17
VFDE	307	1								17
VFDG	308	1								17
VFG	254	1	8							
VFID	251	1				16			18	
VFK	252	1	8							
VFKSP	309	1								17
VFMN	304	1								17
VFQ	253	1	8							
VFRHØ	306	1								17
VH1	290	1								17
VH2	291	1								17
VNNZ	698-708	11				16				
VPNZ	686-696	11				16				
VTID	289	1				16		10	18	17
VTK	1444	1				16				
WAR	241	1	8							
WAREA	240	1	8	14		16				
WCREF	177	1	8							
WDIH	247	1	8							
WEREF	178	1	8							
WSIG	245	1	8				9		18	
WSWP	242	1	8							
WTØC	243	1					9		18	
WTR	244	1	8				9		18	
WWCIX	303	1								17
WWCIY	302	1								17
WWCX	301	1								17
WWCY	300	1								17

TABLE 12. D ARRAY VARIABLES CROSS-REFERENCE LIST (CONCL)

Variable Name	D Array Location	Size	Overlay References							
			8	14	15	16	9	10	18	17
WWPC	299	1								17
WXREF	176	1	8							
WYREF	175	1	8							
XPVT	201	1					9		18	
YAF	145-148	4	8							
YIBTC	141	1	8							
YIHT	360	1	8							
YØBD	139	1	8							
YØBTC	142	1	8							
ZERØ	1403	1					9		18	
ZDIH	248	1	8							
ZNNM	709-719	11				16				
ZNNT	1030-1040	11				16				
ZNZ	86	1				16				

TABLE 13. ARRAY REFERENCES, ARRAY ND

Location	Name	Size	Reference	
			Overlay	Subroutine
1	ND1	1	9,18	DLPVT
			10	CG3P, STRIB, VFCAL
1	N1	1	16	GJTT
1	-	1	8	CAERØ, CASE, CCNTL, DMAX, GEØMC, GEØMW, PRTG, TBWDC
			14	CTØT1, GCNTL, LETEI, LEWT, TEDEV, TEWT
			15	CDL, CTØT2, FDIS, MISCIT, TBFWI1
			16	ALØAD, CNSTC, GJCAL, MTLCW, MTLFW, MTLPW, YBSET
			9	DEADW, DWYBA, PRØG, PRTA, PRTH, TBØPT
			10	BHDJT, BØT, CG3P, CNSTR, EIGJC, SECTD, SFSCH, SRRIB, STBAR, STRG, STRGØ, STWEB, TSCH, VFCAL, WTCAL, WTPIN
			18	ACEIGJ, ACLØAD, ACNSTR, ACPRØG, ASTIFF, ATBØPT, AVLØAD, BHDJT, DEADW, DWYBA, PRTH, WTCAL, WTPIN
			17	CTØT, PINTØ, PRTD, TBFWI, WFLDD, WØDATA, WVFDD
2	ND2	1	9,18	DLPVT
2	N2	1	16	GJTT
2	-	1	8	CCNTL, DMAX, GCØMP, TBWDC
			14	GCNTL, LETEI, LEWT, TEDEV, TEWT, TEWTI, WLETE
			15	CDL, FDIS, MISCIT, PRIM, TBFWI1
			16	ALØAD, CNSTC, GJCAL, MTLCW, MTLFW, VLØAD1, YBSET
			9	CSECW, DWYBA, PRØG, PRTA, TBØPT, VLØAD
			10	BHDJT, BØT, CG3P, CONSTR, EIGJC, PRTB, PRTBK, PRTC, SECTD, SFSCH, SRRIB, STBAR, STRG, STRGØ, STRIB, STWEB, TSCH, VFCAL, WTCAL

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
			18	ACEIGJ, ACLØAD, ACNSTR, ACPRØG, ACPRTA, ASTIFF, ATBØPT, AVLØAD, BHDJT, CSECW, DWYBA, PRTA, PRTC, WEIGH1, WTCAL
			17	PINTØ, PRTD, TBFWI, WFLDD, WØDATA, WVFDD
3	ND3	1	9,18	DLPVT
3	-	1	8	CCNTL
			14	LETEI, TEDEV, TEWTI
			15	CDL, MISCIT, MISCNT
			16	CNSTC, MTLFW
			9	CSECW, PRØG, PRTA, TBØPT
			10	CG3P, CNSTR, PRTBK, SECTD, SFSCH, SRRIB, STBAR, STRG, STRGØ, TSCH, VFCAL, WTPIN
			18	ACEIGJ, ACLØAD, ACPRØG, ASTIFF, AVLØAD, CSECW, WEIGH1, WTPIN
			17	PINTØ, PRTD, WFLDD, WØDATA, WVFDD
4	ND4	1	9,18	DLPVT
4	-	1	8	CCNTL, GEOMW, VSGEØM
			14	CTØT1, GCNTL, LETEI, LEWT, TEDEV, TEWT, TEWTI
			15	CDL, CTØT2, FDIS, MISCIT, MISCNT, PRTM, TBFWI1
			16	ALØAD, GJCAL, MTLFW, WDDATA
			9	CSECW, DWYBA, PRØG, TBØPT
			10	CNSTR, SFSCH, STRG, TSCH, VFCAL, WTPIN
			18	ACEIGJ, ACLØAD, ASTIFF, CSECW, DWYBA, WTPIN
			17	CTØT, PINTØ, PRTD, TBFWI, WFLDD, WØDATA, WVFDD
5	-	1	8	CCNTL, DMAX
			14	TEDEV
			15	CDL, MISCIT
			16	MTLFW

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference: Overlay	Reference: Subroutine
			9	PRØG, PRTA, TBØPT
			10	CNSTR, PRTBK, PRTC, SFSCH, TSCH
			18	ACLØAD, ACPRØG, ACPRTA, PRTC
			17	PINTØ, WVFDD
6	-	1	8	CCNTL, GEØMC, PRTG
			16	ALØAD, MTLFW
			9	PRTA, TBØPT
			10	CNSTR, PRTB, SFSCH, TSCH
			18	ACNSTR, ACPRTA, PRTB
			17	PINTØ, WVFDD
7	-	1	8	CCNTL
			15	FDIS
			10	PRTB, PRTC, SFSCH, STWEB, TSCH
			18	ACNSTR, PRTB, PRTC
			17	PINTØ
8	-	1	8	CCNTL
			14	TEWTI
			15	FDIS, MISCNT
			9	PRTA, PRTH
			10	PRTC, SFSCH, TSCH
			18	ACPRTA, PRTH
			17	PINTØ
9	ND9	1	9,18	DLPVT
9	-	1	8	CCNTL
			15	TBFWI1
			9	PRTH, TBØPT
			10	SFSCH, TSCH
			18	ATBØPT, PRTH
			17	PRTD, TBFWI, WVFDD
10	ND10	1	9,18	DLPVT
10	-	1	8	CCNTL, GCØMP, PRTG
			14	LEWT
			15	CDL, FDIS, MISCIT, TBFWI1
			16	WDDATA
			9	PRØG, PRTA, TBØPT
			10	SFSCH, STWEB, TSCH, WTCAL
			18	ACPRØG, ACPRTA, WTCAL
			17	TBFWI, WVFDD

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
11	N11	1	16	GJTT
11	-	1	8	CAERØ, CCNTL, DMAX, GCØMP, PRTG
			14	CTØT1, GCNTL, LETEI
			15	CDL, CTØT2, FDIS, MISCIT, TBFWI1
			9	DEADW, PRTA
			10	BHDJT, SFSCH, TSCH, WTCAL
			18	ACNSTR, ACPRTA, BHDJT, DEADW, WTCAL
			17	CTØT, PINTØ, TBFWI, WVFDD
12	N12	1	16	CJTT
12	-	1	8	CCNTL
			14	LETEI
			15	CDL, FDIS, MISCIT
			16	ALØAD, GJCAL, GJTT, VLØAD1, WDDATA, YBSET
			9	DWYBA, PRØG, PRTA, PRTH, TBØPT, VLØAD
			10	BØT, CNSTR, EIGJC, PRTB, PRTC, SFSCH, SECTD, WTCAL, WTPIN
			18	ACLØAD, ACNSTR, ACPRØG, ACPRTA, AVLØAD, DWYBA, PRTB, PRTC, PRTH, WTCAL, WTPIN
			17	PINTØ, WØDATA, WVFDD
13	-	1	8	CCNTL
			9	SFSCH
14	-	1	8	CCNTL
			9	SFSCH
15	-	1	8	CCNTL
			9	SFSCH
16	-	1	8	CCNTL
			9	TSCH
17	-	1	8	CCNTL
			9	TSCH
18	-	1	8	CCNTL
			9	TSCH

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
19	-	1	8	CCNTL
			10	EIGJC
20	-	1	8	CCNTL
21	MATLI	1	16	MTLCW, MTLFW, MTLPW
			17	PRTD
22	ISC	1	16	CNSTC
			9	PRØG, SECTD, TBØPT
23	IPA	1	9	TBØPT
			18	ATBØPT
24	IPB	1	9	TBØPT
			10	CNSTR
			18	ACNSTR, ATBØPT
25	NDWP	1	9	PRØG
			18	ACPRØG
26	I	1	8	CASE
			14	GCNTL, LETEI, LEWT, TEDEV, TEWT, TEWTI
			15	CDL, FDIS, MISCIT, MISCNT, TBFWI1
			17	TBFWI
	J	1	9	DWYBA
			18	DWYBA
	LT1	1	10	TSCH
	NN	1	16	MTLCW, MTLPW
27	I	1	9	PRTA
			17	PRTD
	J	1	16	YBSET
	L	1	9,18	DWYBA
	LT2	1	10	TSCH
	M	1	17	WVFDD
	N	1	14	GCNTL, LETEI, LEWT, TEDEV, TEWT, TEWTI
			15	CDL, FDIS, MISCIT, MISCNT, PRTM, TBFWI1
			9	PRØG
			18	ACPRØG
			17	TBFWI
28	I	1	16	YBSET
			9	PRØG

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
			10	PRTB
			18	ACPRØG, PRTB
	IRGØ	1	10	PRTBK
	J	1	9	PRTA
			17	PRTD
	K	1	14	GCNTL
	L	1	14	TEDEV, TEWT
			15	CDL, FDIS, MISCIT, MISCNT, PRTM
			16	MTFLW
			9,18	CSECW
			17	WFLDD, WVFDD
	LT3	1	10	TSCH
	M	1	9,18	DWYBA, DLPVT
	N	1	10,18	WTCAL
	NA	1	14	LETEI
29	I	1	16	ALØAD
			9	TBØPT
			10	CNSTR, PRTC, SECTD, SFSCH, TSCH, WTCAL
			18	ACLØAD, PRTC, WTCAL
			17	PINTØ, WFLDD, WØDATA, WVFDD
	J	1	15	CDL, MISCIT
			10,18	PRTB
	K	1	15	TBFWI1
			16	MTLFW, YBSET
			9	CSECW, DEADW, DLPVT, DWYBA, PRØG
			10	PRTBK
			18	ACPRØG, CSECW, DEADW, DLPVT, DWYBA
			17	PRTD, TBFWI
	KK	1	8	DMAX
	LCCR	1	18	ACMRSK, ACWSTR
	NS	1	14	LETEI
30	I	1	9,18	DEADW
			10	BØT, EIGJC
	IN	1	10	TSCH, SFSCH
	J	1	16	ABDW, CNSTC
			9	CSECW, DLPVT

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
			10	VFCAL, WTPIN
			18	CSECW, DLPVT, WTPIN
	K	1	14	LEWT, TEDEV, TEWT
			15	CDL, FDIS, MISCIT, MISCNT
			16	ALØAD
			9	PRTA
			10	CNSTR, PRTB, PRTC
			18	ACLØAD, PRTB, PRTC
	KD	1	14	LETEI
	L	1	17	PRTD
	N	1	8	ABØXC, GEØMW
			14	TEWTI
			16	MTLFW, VLØAD1
			9	VLØAD
			10	PRTBK, STWEB
			18	ATBØPT, AVLØAD
			17	PINTØ, WFLDD, WVFDD
	NS	1	15	TBFWI1
			17	TBFWI
31	I	1	16	CNSTC, MTLCW, MTLFW, MTLPW
			9,18	CSECW
			10	PRTBK
	IK	1	14	LETEI
	IWD	1	8	TBWDC
	K	1	16	VLØAD1
			9	VLØAD
			18	AVLØAD
			17	PINTØ, WFLDD, WVFDD
	KK	1	10	BØT
	M	1	14	LEWT, TEDEV, TEWTI
			15	CDL, FDIS, MISCIT
	N	1	16	ABDW, ALØAD
			9	DEADW, DLPVT, PRTA, PRTH, TBØPT
			10	CNSTC, PRTB, PRTC, SFSCH, STRIB, TSCH, VFCAL, WTPIN
			18	ACLØAD, DEADW, DLPVT, PRTB, PRTC, PRTH, WTPIN
			17	PRTD

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
	NA	1	15	TBFWI1
			17	TBFWI
	NMAX	1	18	ACMRSK, ACWFDH, ACWMS, ACWRBS, ACWSTR, CKSFDH, CKSTAB
32	I	1	17	TPINT
	IFD	1	14	TEDEV, TEWTI
	IKI	1	10	BØT, SECTD, SFSCH
	KD	1	15	TBFWI1
			17	TBFWI
	NSKIN	1	18	ACMRSK, ACWSTR
33	IFK	1	14	TEDEV
	IMØ	1	10	STBAR
	IP2	1	15	MISCIT, PRTM
	NSTIFF	1	18	ACSTRG, ACWSTR
34	IL	1	10	STBAR
	IL1	1	10	TSCH
	1LS	1	18	ACWSTR
35	IL2	1	10	TSCH
	IM	1	10	STRG
	IMN	1	10	STBAR
	NLS	1	18	ACWSTR
36	IL3	1	10	TSCH
	NLR	1	18	ACWSTR
37	IWEB	1	10	SECTD, STWEB
	LSTRCR	1	18	ACMRSK
38	NI	1	10	SRRIB, STRIB
39	IK	1	10	BØT, CG3P, PRTBK, SFSCH, STRG, STWEB, TSCH
	KI	1	10	STRIB
40	IL	1	10	CG3P, TSCH, SFSCH
41	ILCASE	1	18	ACLØAD, ACMRSK, ACPRØG, ACWFDH, ACWMS, ACWRBS, ACWSTR, TEMPC
	KFC	1	10	SFSCH
	N1	1	10	VFCAL
42	LF1	1	10	SFSCH
	N2	1	10	VFCAL
	SKCØDE	1	18	ACWMS, ACWRBS, WEIGH1
43	LF2	1	10	SFSCH

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
	N3	1	10	VFCAL
	SPCØDE		18	ACWMS, ACWRBS, ACWSTR, WEIGH1, WEIGH2
44	LF3	1	10	SFSCH
	N4	1	10	VFCAL
	TYPE	1	18	ACWMS, ACWRBS, ACWSTR
45	IØ1	1	10	SFSCH
	ISK1	1	10	TSCH
	SFCØDE	1	18	ACWMS, ACWRBS, WEIGH1, WEIGH2
46	IØ2	1	10	SFSCH
	ISK2	1	10	TSCH
	SRCØDE	1	18	ACWMS, ACWRBS, WEIGH1, WEIGH2
47	IC	1	9,18	DLPVT
	ICB	1	10,18	BHDJT
	IMX	1	10	SFSCH
48	IC	1	10	CNSTR, WTCAL
			18	ACNSTR, WTCAL
49	ICD	1	16	CNSTC
			9	TBØPT
			10	CNSTR, SECTD
50	IDVF	1	10	SECTD
51	IDSK	1	10	TSCH
	IVF	1	10	CNSTR, EIGJC, PRTB, PRTC, SECTD, SFSCH, VFCAL
			18	PRTB, PRTC
52	IB	1	10	SECTD, SFSCH
53	IVFJT	1	16	CNSTC
			10	PRTB, VFCAL
			18	PRTB
54	LID	1	8	CASE
			16	ABDW, ALØAD, VLØAD1
			9	VLØAD
			18	AVLØAD
55	ISEC	1	8	ABØXC, TBWDC
			10	BHDJT, CNSTR, EIGJC, PRTB, PRTBK, PRTC, SECTD, SFSCH, STWEB, WTCAL, WTPIN
			18	ACNSTR, BHDJT, PRTB, PRTC, WTCAL, WTPIN

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
	NSTAT	1	18	ACMRSK, ACSTRG, ACWMS, ACWRBS, ACWSTR, CKSFDH, CKSTAB
55	-	1	10	CG3P
56	NØDW	1	16	VLØAD1
			9	DEADW, DWYBA, PRØG, PRTA, PRTH, TBØPT, VLØAD
			10	CNSTR, PRTB, PRTBK
			18	ACPRØG, ACPRTA, ATBØPT, AVLØAD, DEADW, DWYBA, PRTB, PRTH
56	-	1	10	CG3P
57	IGT	1	9	PRØG, TBØPT
	IGW	1	9	DLPVT, PIVØT, PRTH
			10	PRTB, PRTC
			18	DLPVT, PIVØT, PRTB, PRTC, PRTH
58	-	-	-	Not used
59	NMATL	1	8	CCNTL
			16	MTLCW
60	NCASE	1	8	CCNTL, PRTG
			14	WLETE
			16	ABDW, ALØAD, GJTT, MTLPW, VLØAD1
			9	DEADW, DWYBA, PIVØT, PRTA, PRTH, VLØAD
			10	PRTB, PRTC
			18	ACLØAD, ACPRTA, AVLØAD, DEADW, DWYBA, PIVØT, PRTB, PRTC, PRTH
			17	PINTØ, PRTD, WFLDD, WØDATA
61	IGW	1	16	VLØAD1
			9	DEADW, DWYBA, PRØG, PRTA, TBØPT, VLØAD
			18	ACPRØG, ACPRTA, ATBØPT, AVLØAD, DEADW, DWYBA
			17	WØDATA
62	ISEC	1	18	ACWMS, ACWRBS
63	-	-	-	Not used
64	-	-	-	Not used
65				

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONT)

Location	Name	Size	Reference	
			Overlay	Subroutine
66	ILWRC	1	10	SECTD
67	NAF	1	8	DMAX, GEØMC
68	NCSEC	1	8	TBWDC
			16	ALØAD
			10	CNSTR
69	-	-	-	Not used
70	IRG	1	10	STRG, STRGØ
71	IMX	1	10	SECTD, STRG, STRGØ, TSCH
72	IBT	1	10	SECTD, TSCH
73	IØPT	1	9	TBØPT
74	IØPI	1	9	PRØG, PRTA, TBØPT
			10	CNSTR
75	IØPD	5	9	TBØPT
76	-	-	-	Not used
77	-	-	-	Not used
78	-	-	-	Not used
79	-	-	-	Not used
80	IØPJ	1	9	PRTA, TBØPT
			10	CNSTR
81	IØPP	1	9	PRTA, TBØPT
82	IØP1	1	16	VLØAD1
			9	PRØG, PRTA, PRTH, TBØPT, VLØAD
			10	CNSTR, PRTB, PRTC
			18	AVLØAD, PRTB, PRTC, PRTH
83	IØPS	1	9	PRØG
84	IØPC	1	9	PRØG
85	NPAGE	1	8	CCNTL
			9	PRTA
			18	ACPRTA
86	ISG	1	10	SFSCH
87	ISTB	1	10	TSCH
88	ISTRG	1	10	STRG
89	-	-	-	Not used
90	-	-	-	Not used
91	-	-	-	Not used
92	IF3	1	16	MTLCW
			9	CNSTR
93	IF4	1	9	PRØG, TBØPT
			18	ACPRØG, ATBØPT

TABLE 13. ARRAY REFERENCES, ARRAY ND (CONCL)

Location	Name	Size	Reference	
			Overlay	Subroutine
94	-	-	-	Not used
95	-	-	-	Not used
96	-	-	-	Not used
97	IF8	1	9	PRØG
			18	ACPRØG
			17	WØDATA
98	-	-	-	Not used
99	-	-	-	Not used
100	-	-	-	Not used

TABLE 14. ARRAY REFERENCES, ARRAY DC

Location	Name	Size	Reference	
			Overlay	Subroutine
1	-	1	17	WVFDD
2	-	1	17	WVFDD
3	ZERØ	1	9,18	DLPVT
3	-	1	8	ABØXC, CASE, DMAX, GCØMP, GEØMC, GEØMW, PRTG, TBWDC, VSGEØM
			14	GCNTL, LETEI, LEWT, TEDEV, TEWT, TEWTI, WLETE
			15	CDL, FDIS, MISCIT, MISCNT, TBFWI1
			16	ABDW, ALØAD, CNSTC, GJCAL, GJTT, MTLFW, VLØAD1, WDDATA, YBSET
			9	CSECW, DEADW, PRØG, PRTA, TBØPT, VLØAD
			10	BHDJT, BØT, CNSTR, EIGJC, RTRIB, SECTD, SFSCH, STBAR, STRG, STRIB, STRIL, STWEB, TSCH, VFCAL, WTCAL,WTPIN
			18	ACEIGJ, ACLOAD, ACNSTR, ACPRØG, ACPRTA, ACWSTR, ATBØPT, AVLØAD, BHDJT, CSECW, DEADW, RTRIB, WTCAL, WTPIN
			17	PRTD, TBFWI, WFLDD, WØDATA, WVFDD
4	DFREIK	1	18	ACEIGJ
4	-	1	10	EIGJC
5	-	1	17	WVFDD
6	-	1	17	WVFDD
7	-	1	17	WVFDD
8	-	1	17	WVFDD
9	-	1	17	WVFDD
10	-	1	17	WVFDD
11	-	1	17	WVFDD
12	-	1	17	WVFDD
13	-	1	9	PRTA
14	-	1	17	WVFDD
15	-	1	17	WVFDD
16	-	1	17	WVFDD

TABLE 14. ARRAY REFERENCES, ARRAY DC (CONCL)

Location	Name	Size	Reference	
			Overlay	Subroutine
17-31	-	-	-	Not used
32	-	1	16	GJCAL
33	Q0	1	16	GJTT
33	-	1	16	GJCAL
34	-	1	16	GJCAL
35	PT8	1	16	GJTT
35	-	1	16	GJCAL
36	PT4	1	16	GJTT
36	-	1	16	GJCAL
37	PT7	1	16	GJTT
37	-	1	16	GJCAL
38	CØS10	1	16	GJTT
38	-	1	16	GJCAL
39	SIN10	1	16	GJTT
39	-	1	16	GJCAL
40	-	-	-	Not used
41	-	1	16	GJCAL
42	-	1	16	GJCAL
43	G0FPS	1	16	GJTT
44	VTK	1	16	GJTT
45-59	-	-	-	Not used
60	-	1	10	BØTC
61	-	1	10	BØTC
62-69	-	-	-	Not used
70-100	-	-	-	D array references (refer to Tables 8 and 10.)

Section II

METHODOLOGY

INTRODUCTION

The wing and empennage module of SWEEP is a fully integrated module that analytically determines weight and mass distributions of the major structural components of lifting surfaces. The developed logic and analytical procedures are designed for use during preliminary design phases of aircraft design. Logic for assumptions and optional computational procedures are programmed and data manipulation designed so that this module can be used from the initial conceptual period through the point design study phase of preliminary design. However, the program is geared primarily to provide quick but rational estimates of weight, weight distributions, and preliminary estimates of design criteria and requirements in a phase zero operational environment, when only minimal engineering data are available and fast reaction time is important.

One of the primary objectives toward which the logic and computational routines are structured is to produce weight sensitivities to (1) configuration-oriented lifting surface geometry, (2) vehicle design criteria and specifications, (3) structural design criteria and specifications, and (4) fabrication and design-oriented criteria and constraints.

The program is basically designed to evaluate wing surfaces of fixed or variable-sweep designs primarily constructed of metallic materials. Minor logic changes plus inclusion of additional analysis routines and input data allow for analysis of empennage surfaces, including T-tail configurations. Torque boxes constructed of advanced composite materials such as boron/epoxy and graphite/epoxy are evaluated by execution of a separate segment of the module. This segment consists of analysis routines designed to synthesize and evaluate torque box components using procedures similar to those used for metallic analysis. Similar assumptions for structural idealization, external load reactions, structural synthesis, and weight analysis are made, where possible, to insure compatible results between the two methods.

Lifting surfaces are treated as long slender cantilever beams resisting shears and bending moments through a system of covers and supporting structures. A three-dimensional approximation of the main box structure is modeled from planform geometry and airfoil parameters so that cover and support structure weights can be synthesized at 11 structural stations to satisfy imposed constraints of vehicle criteria and design. The synthesis technique considers design criteria and loadings, physical geometries, material properties, types of construction, fabrication and design constraints, etc, in the development of structural sections which are optimized to satisfy strength, stiffness, and stability of the cover and support structures. The synthesized structural

data are used in determining weight and weight distributions by a weight evaluation routine. The estimates are based on volumetric integration of the optimized structural requirements to which weight indexing factors are applied; weight increments for unique and/or local structure requirements such as discontinuities, cutouts, splices, etc, are determined through control indicators and weight factors. Leading edge, trailing edge, tip, and secondary structural component weights are computed from program-derived geometric data, statistical, and vehicle environment data.

The module consists of five interrelated sections programmed for an integrated analysis of lifting surfaces:

1. Mathematical description of the physical features of the general lifting surface and structural component geometries

2. Synthesis and/or processing of design criteria and requirements

3. Structural synthesis of the primary structural box

4. Mass properties evaluation of the major structural components of the lifting surface

5. Processing and tabular output of results of mass properties prediction and optional output of results of the preceding four design synthesis and analysis

Figure 13 is a functional flow diagram showing the major parts of the wing and empennage weight estimation module. The iteration loop includes required logic programmed to (1) damp out effects of design loads changes resulting from differences in assumed to calculated torque box weights, and (2) damp out effects of couple arm changes resulting from changes in torque box cover requirements. Figure 14 shows the general logic and evaluation subroutine flow for the module metallic analysis. Logic and evaluation flow for advanced composite designs is similar, except for the detail analysis procedures used for torque box synthesis and optimization.

The structural synthesis/weight analysis scheme provides a detailed evaluation of the structural requirements and mass properties characteristics of lifting surface structures by treating each major component separately. Weights are synthesized at various control points on the planform based on specifications in the input data set and processed into a weight distribution surface (Figure 15). The surface is integrated numerically for necessary mass properties data.

The wing and empennage module consists of eight overlays with subprograms written to perform one or more of the five tasks previously listed. The first overlay, overlay (8,0), includes the subroutines that compute necessary

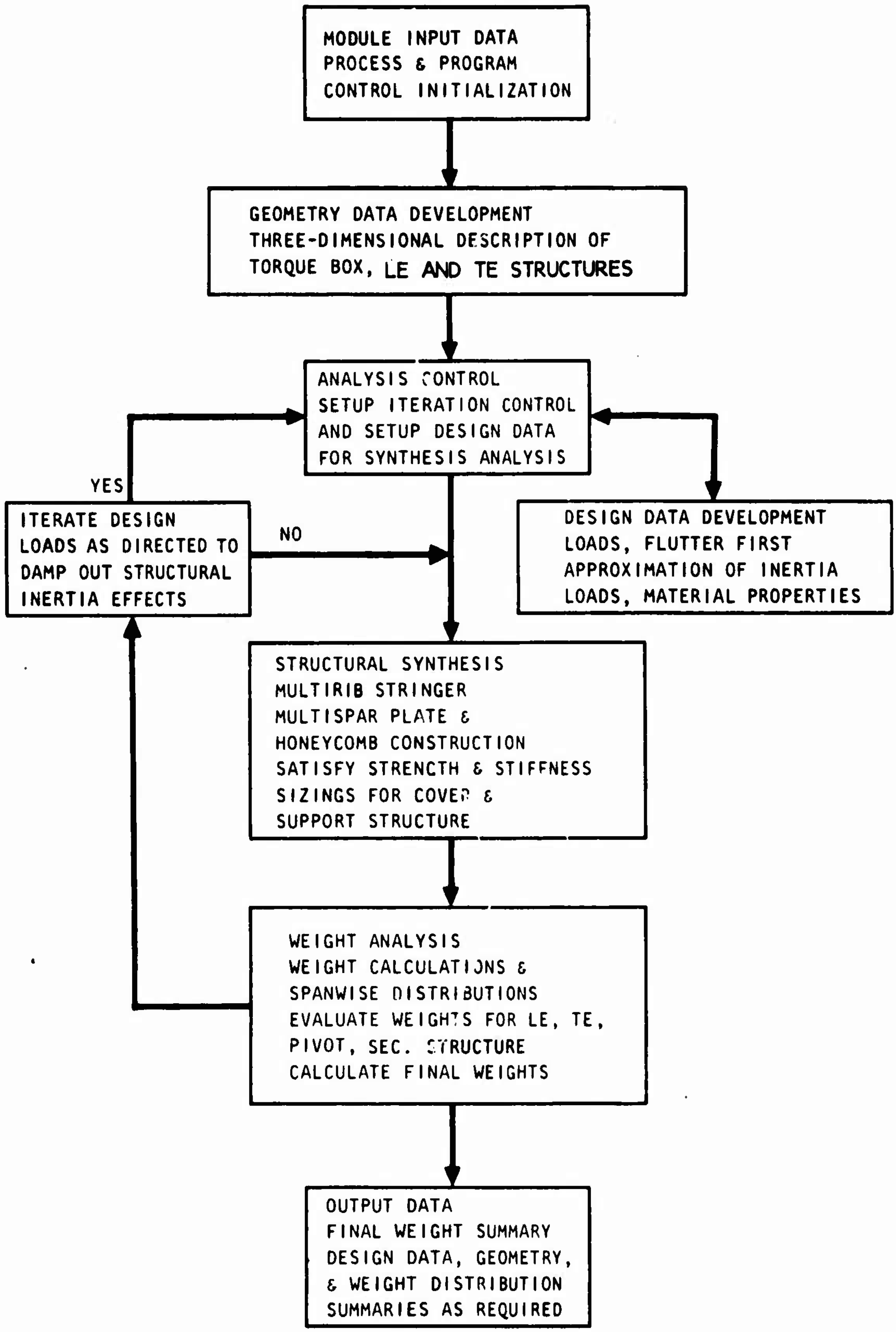


Figure 13. General program functional flow diagram.

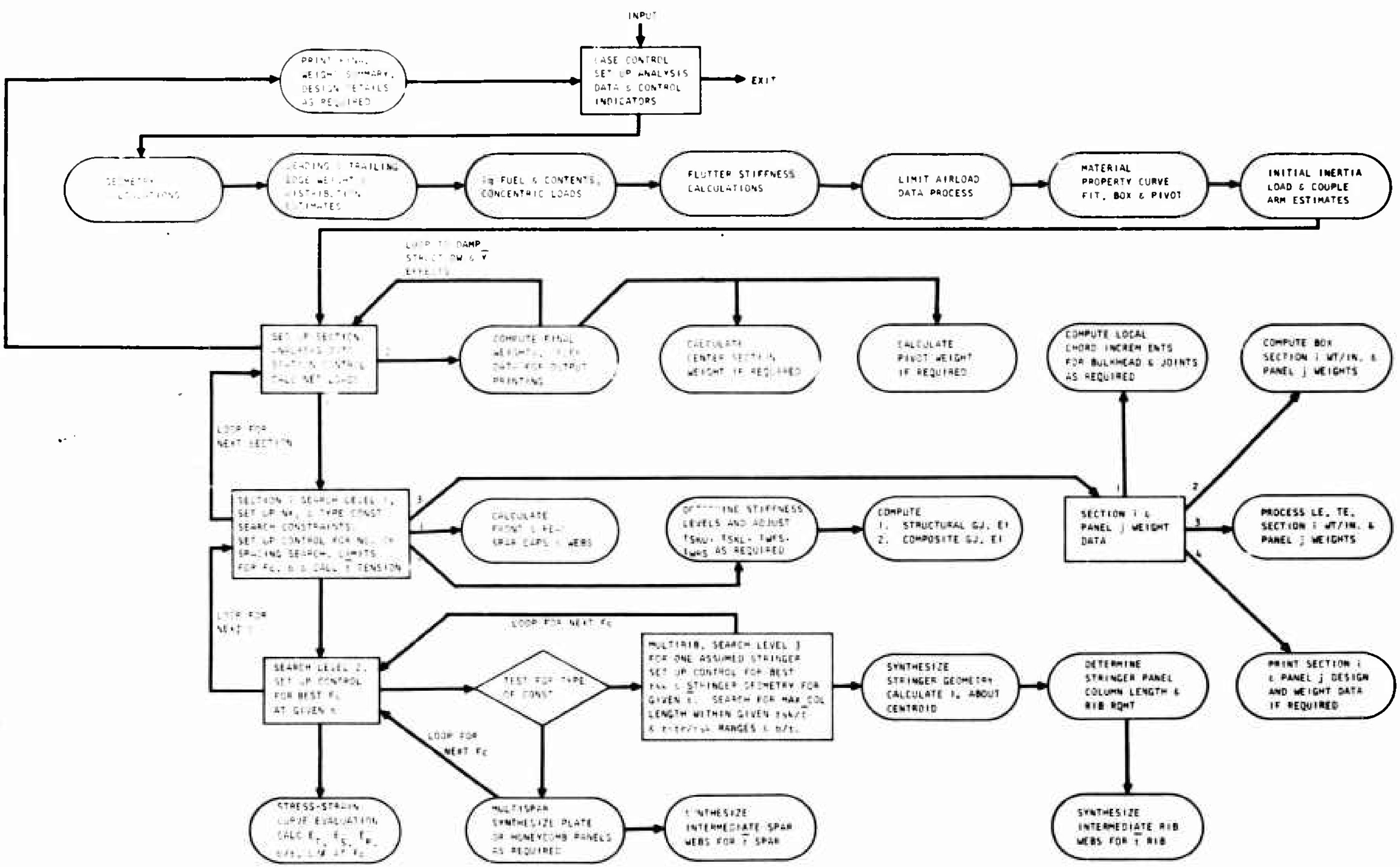


Figure 14. Logic and execution subroutine flow diagram for lifting surface structural weight estimating module.

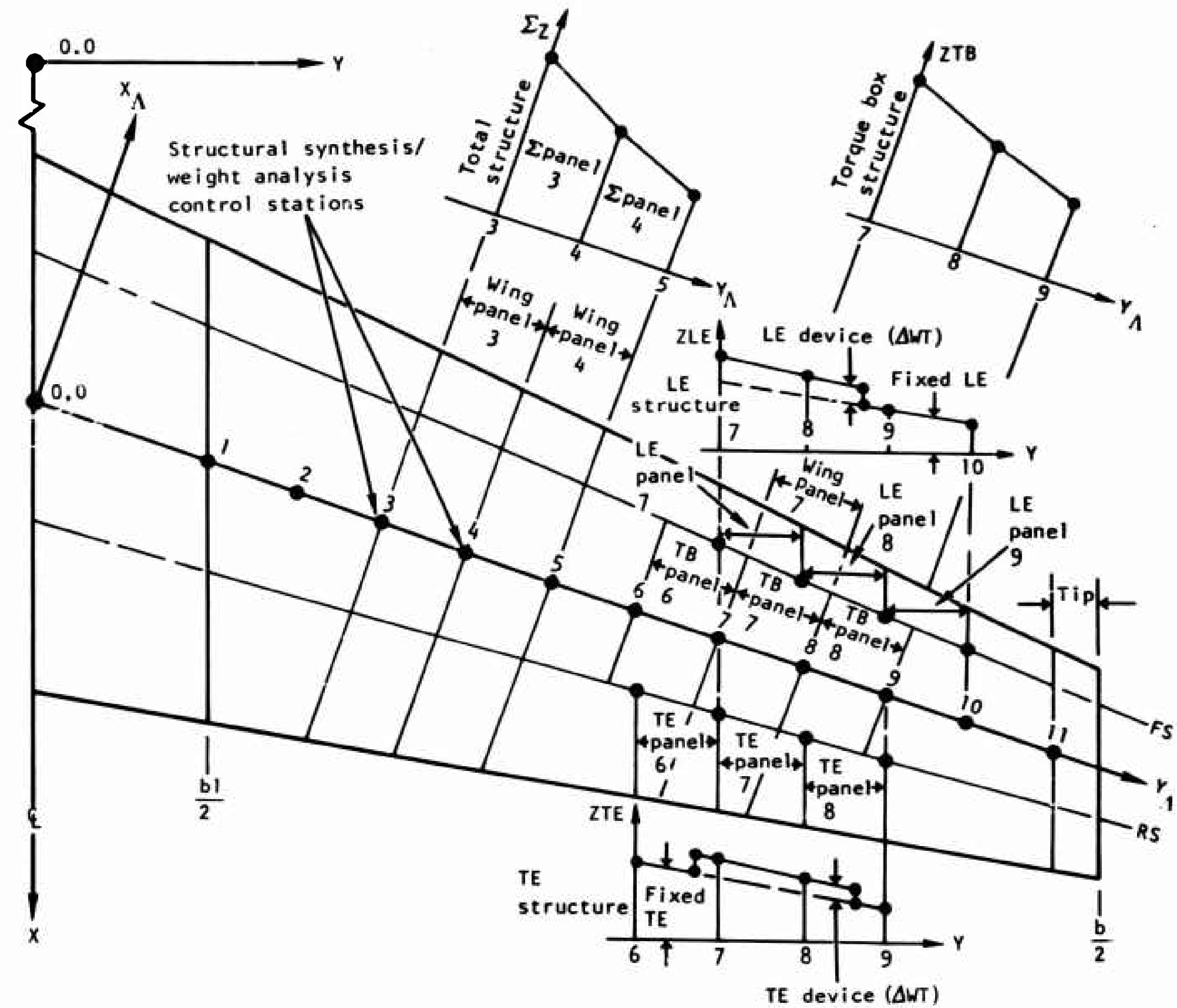


Figure 15. Structural synthesis/weight analysis reference system and weight integration.

geometry data for use by the other seven overlays. Design data for the synthesis of the torque box are computed and organized by the routines in overlay (16,0). Overlays (14,0) and (15,0) are weight analysis overlays. Mass properties estimates are made by routines in these overlays for the synthesis analysis; leading edge, trailing edge, store fitting, and tip structure weight estimates are made by these overlays for the final estimates of these structures.

Overlays (9,0), (10,0), and (18,0) include the control and evaluation routines for the structural synthesis and weight analysis of the primary load-carrying components. Metallic structures are analyzed with overlays (9,0) and (10,0); advanced composite structures by overlay (18,0).

Overlay (17,0) includes the primary lifting surface weight and design summary output routines. Other print subroutines are included in all overlays, for output of analysis results on option of the user.

LIFTING SURFACE GEOMETRY

Wing and empennage planforms are described by a system of lines based on the orthogonal coordinate system shown in Figure 16. The air vehicle centerline is the X-axis (positive aft), with the apex station as the reference point to position the wing or empennage surface relative to the other structural components of a given vehicle configuration. The Y-axis is parallel to surface buttock plane stations (positive outboard); the Z-axis is normal to the X-Y plane defining vehicle water planes (positive up). All planform line equations used for geometry description are expressed in the form:

$$X = a\,(Y) + C \tag{1}$$

Where

X = X-coordinate, in.

Y = Y-coordinate, in.

a = slope of line (tangent of sweep of line relative to Y-axis (positive aft)

C = X-axis intercept of line (fuselage station)

PLANFORM GEOMETRY

Conventional aerodynamic expressions for the theoretical trapezoidal planform geometry of lifting surfaces are used to define the reference outline of the surface (Figure 16). Pertinent geometric line and control points and all other required data are developed from the relationships of:

$$b = \frac{(AR \times S)^{1/2}}{144} \tag{2}$$

$$S = \frac{(b/2)\ C_R\ (1 + \lambda)}{144} \tag{3}$$

$$C_T = \lambda\, C_R \tag{4}$$

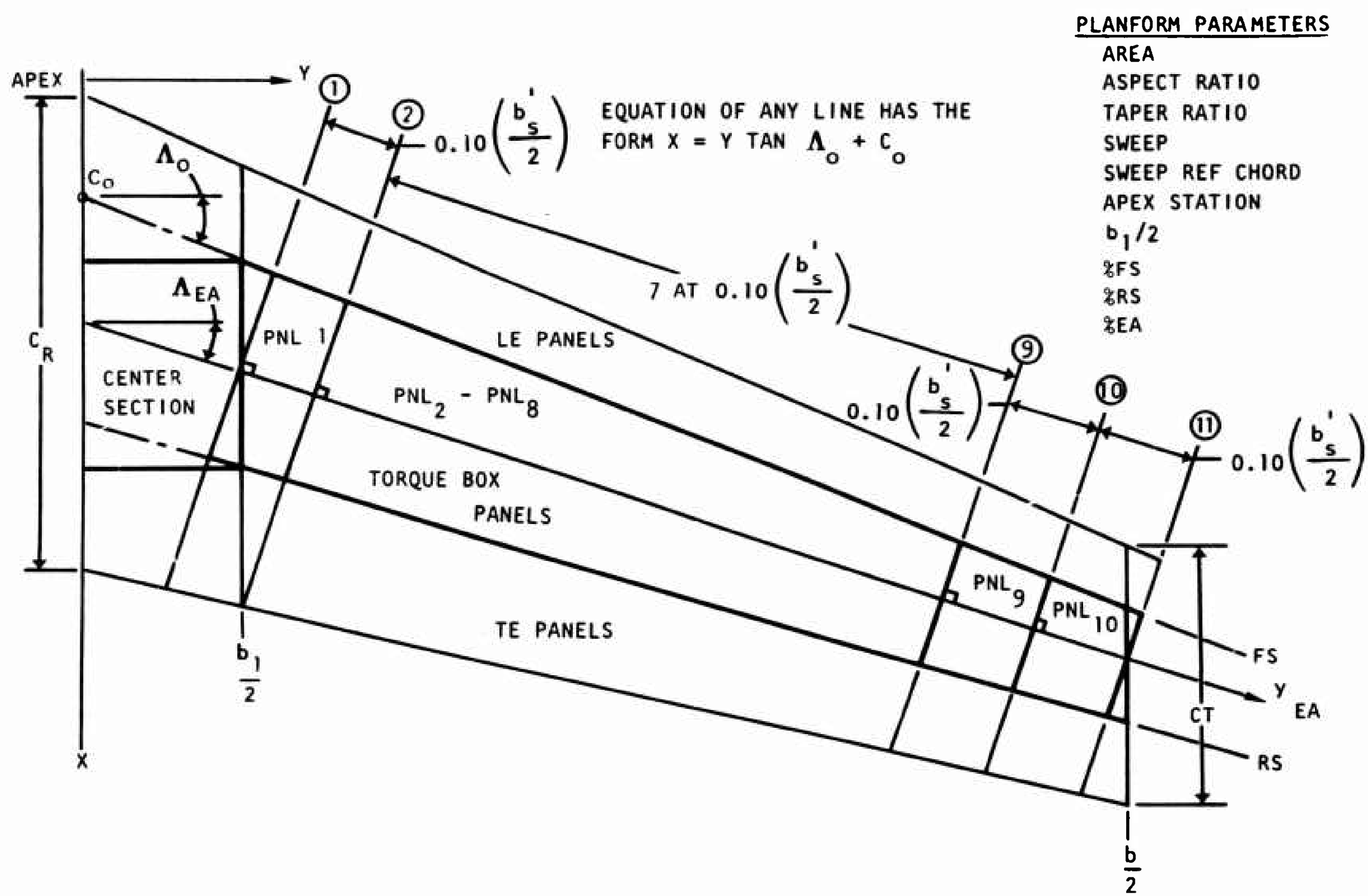


Figure 16. Idealized lifting surface planform.

Where

S = theoretical planform area, sq ft

AR = planform aerodynamic aspect ratio

λ = planform taper ratio

b = surface aerodynamic span, in.

C_R = centerline planform aerodynamic chord, in.

C_T = planform tip chord, in.

The sweep of a reference chord, Λ reference (quarter chord, leading edge, etc), and the apex fuselage station provides the required data to position the spanwise chords relative to the centerline chord, and the planform relative to the fuselage. Slopes of chord element lines other than the reference chord line are determined from one of the following expressions:

$$TAN_{\Lambda_i} = TAN_{\Lambda_R} + \frac{4}{AR}\left[\frac{(1-\lambda)}{(1+\lambda)}\right]\left[(\Delta X)_R - (\Delta X)_i\right] \tag{5a}$$

$$TAN_{\Lambda_i} = \frac{X_{TIP} - X_R}{b/2} \tag{5b}$$

Where

ΔX_i = chord element line expressed as a fraction of total aerodynamic chord

X_{tip} = X-coordinate of chord element line at planform tip

X_R = X-coordinate of chord element line at X-axis

The X-intercept of chord element lines is determined from the expression:

$$C_L' = X_{APEX} + \Delta X_i \, C_R \tag{6}$$

For computational purposes, the aerodynamic chord at any spanwise Y-station is determined from:

$$C_a = Y \cdot TAN(AC) + C_R$$

$$TAN(AC) = \frac{C_{TIP} - C_R}{b/2} \qquad (6a)$$

All pertinent structural reference lines and coordinates, blended leading edge, and cranked trailing edge control points are referenced to the theoretical trapezoided planform. Any required coordinate point is defined to the module through the input data set by one of the following:

1. Fraction of the semispan for Y, and fraction of the local aerodynamic chord for X

2. Actual buttock plane station for Y, and actual delta chord forward or aft of the local leading edge for X

The input data set is ordered so that pertinent geometric coordinates can be specified, as required, to describe torque box location, fuel cell location, physical dimensions, locations of control surface devices, locations of externally mounted stores or nacelles, etc. Nontrapezoidal surfaces (Figure 17) are defined to the general geometry routines by a system of points defining delta chords to be incremented to the local trapezoidal leading or trailing X-coordinate. Adjusted leading or trailing edges between control points are assumed to be represented by straight lines between the control points. Assumed true aerodynamic chord is determined from evaluation of the proper straight-line expressions for the adjusted local leading and trailing edge.

The general coordinate specification method used in the input data set and the equation form of expressing spanwise lines provide flexibility in defining load reference lines, weight integration lines, and/or spar planes not on aerodynamic chord element lines.

For the torque box system shown in Figure 16, if the assumed elastic axis and rear spars are on the 35- and 60-percent chord element lines, the front spar plane is defined by a point 20 inches aft of the leading edge at the wing-to-fuselage joint and the 15-percent chord point at 80 percent of the

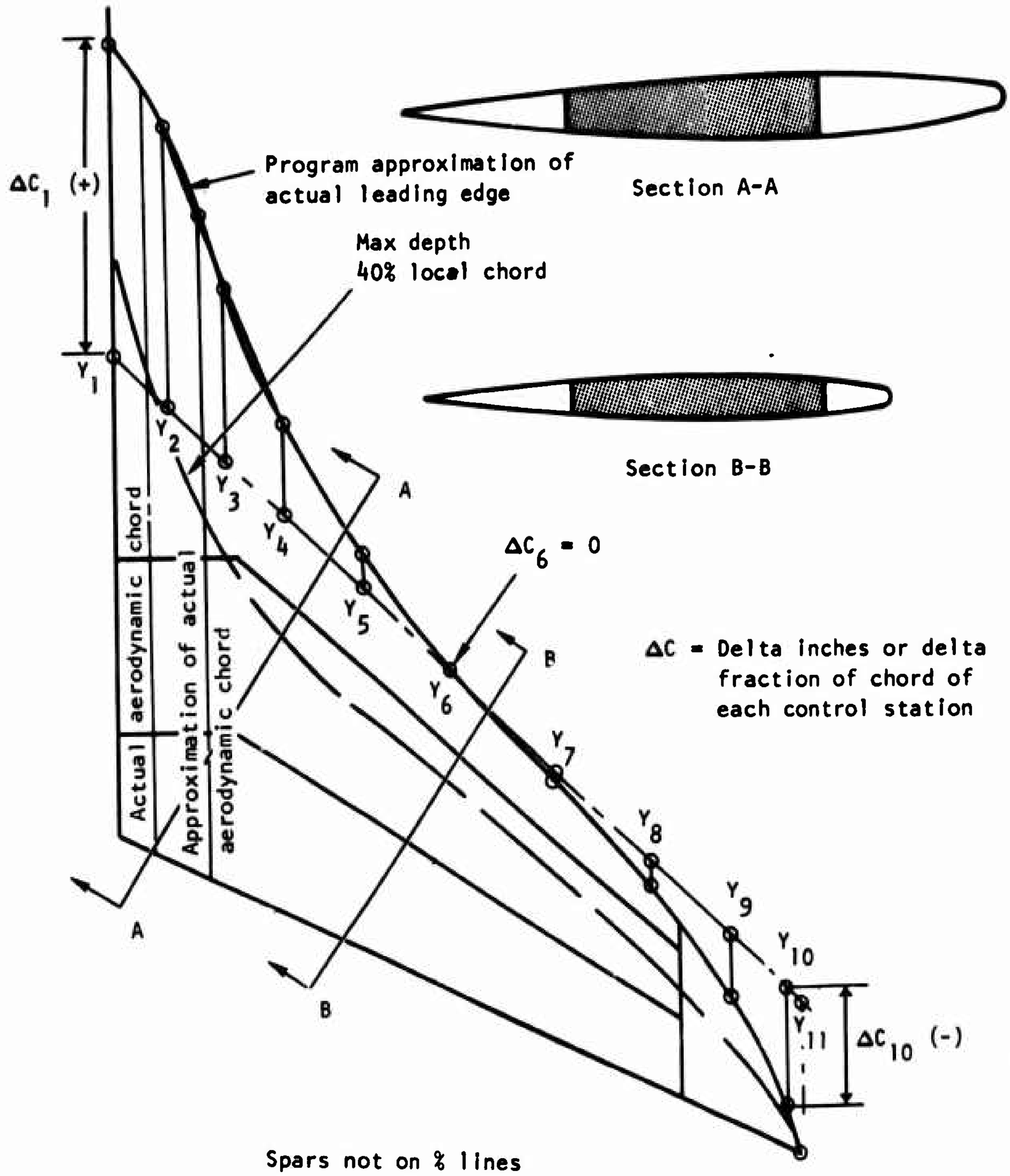


Figure 17. Blended wing planform.

exposed span, and the torque box extends to the buttock plane at 95 percent of the semispan, 10 data points must be included in the input data set. These include:

1. Inboard shear tie location, $b_1/2$

2. Outermost torque box station, $Y_{\emptyset B}$, which will be assumed to be the eleventh station in the structural synethesis, 0.95

3. Inboard box control station, $b_1/2$

4. Front spar chordwise control station, inboard, 20.0

5. Rear spar chordwise control station, inboard, 0.60

6. Elastic axis chordwise control station, inboard, 0.35.

7. Outboard box control station, 0.80

8. Front spar chordwise control station, outboard, 0.15

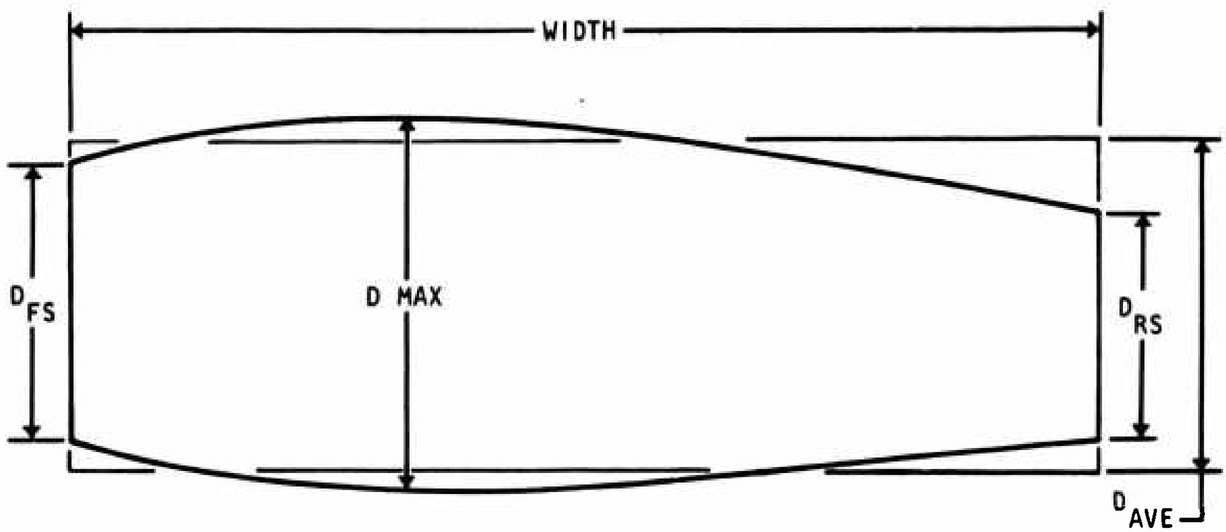
9. Rear spar chordwise control station, outboard, 0.60

10. Elastic axis chordwise control station, outboard, 0.35

CROSS-SECTIONAL GEOMETRY

Spanwise airfoil and thickness ratio specifications for lifting surfaces are used to define aerodynamic cross sections. These data, along with the planform description of the torque box, provide the basis for determining the physical box data necessary for the structural synthesis and weight analysis of the lifting surface (structural box width, maximum and minimum box depth, structural box cross-sectional area, and mold line depths at the front and rear spar planes). Figure 18 shows the idealized box section used for structural synthesis. Figure 19 shows the spanwise variations in structural box depth for the blended wing parameters found in Figure 20. As indicated, the generalized cross-section evaluation procedure accounts for nonlinear spanwise and chordwise airfoil depth variations. In all cases, the specified aerodynamic airfoil is assumed for the true computed aerodynamic chord; at the depth control stations, the maximum depth is derived from the product of the specified t/c and the true chord.

Airfoil depth at any planform point is determined by straight-line interpolation of maximum depths at spanwise control points and from normalized local chordwise airfoil depth data. Maximum depth control points can be defined at two to 11 spanwise stations in the input data set by specifying the location of the control station and the thickness ratio at that point.



$$D_{AVE} = \frac{\text{X-SEC AREA}}{\text{WIDTH}}$$

$$\Sigma ds = 2 \cdot \text{WIDTH} + D_{FS} + D_{RS}$$

Figure 18. Idealized box section.

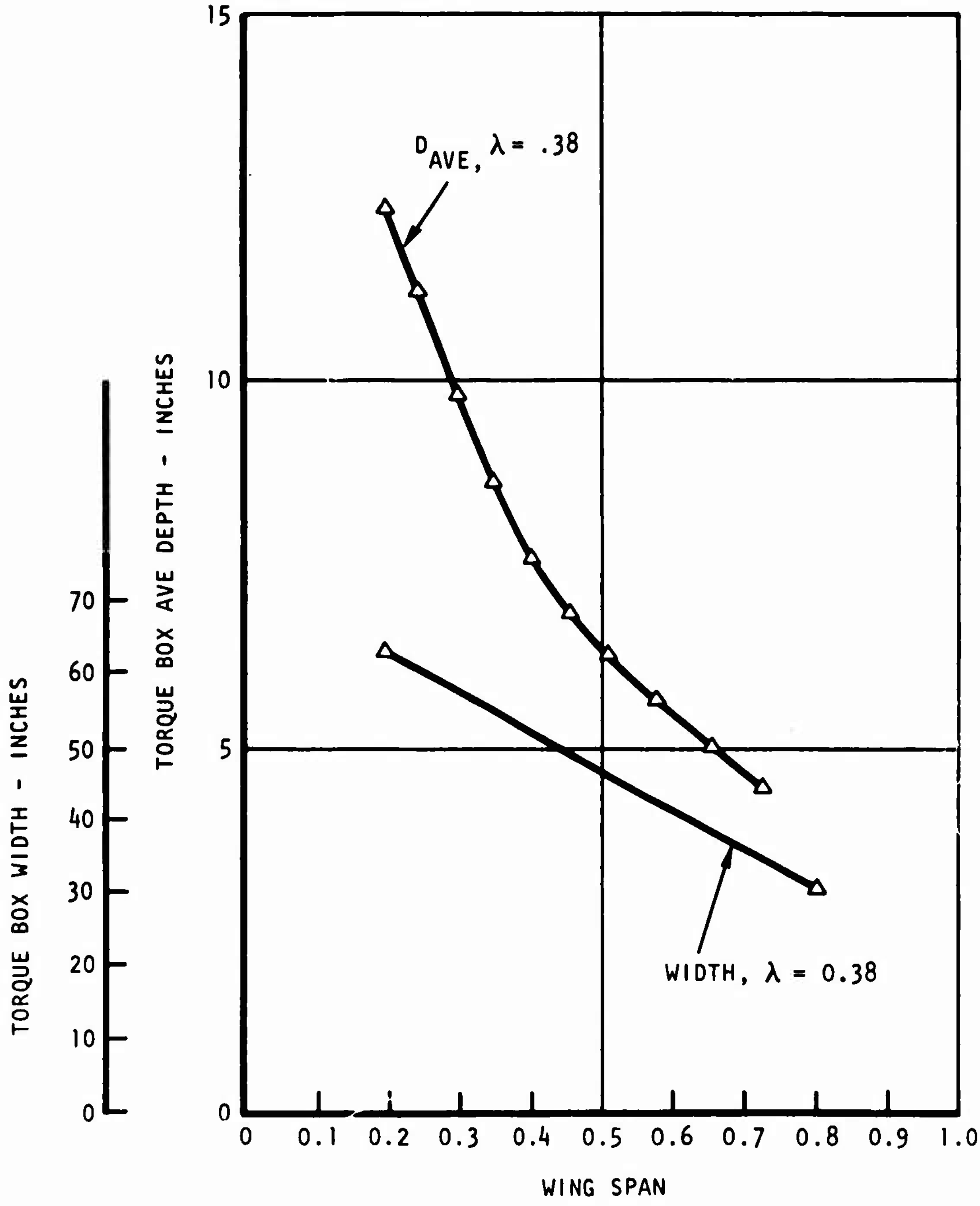


Figure 19. Blended wing torque-box geometry.

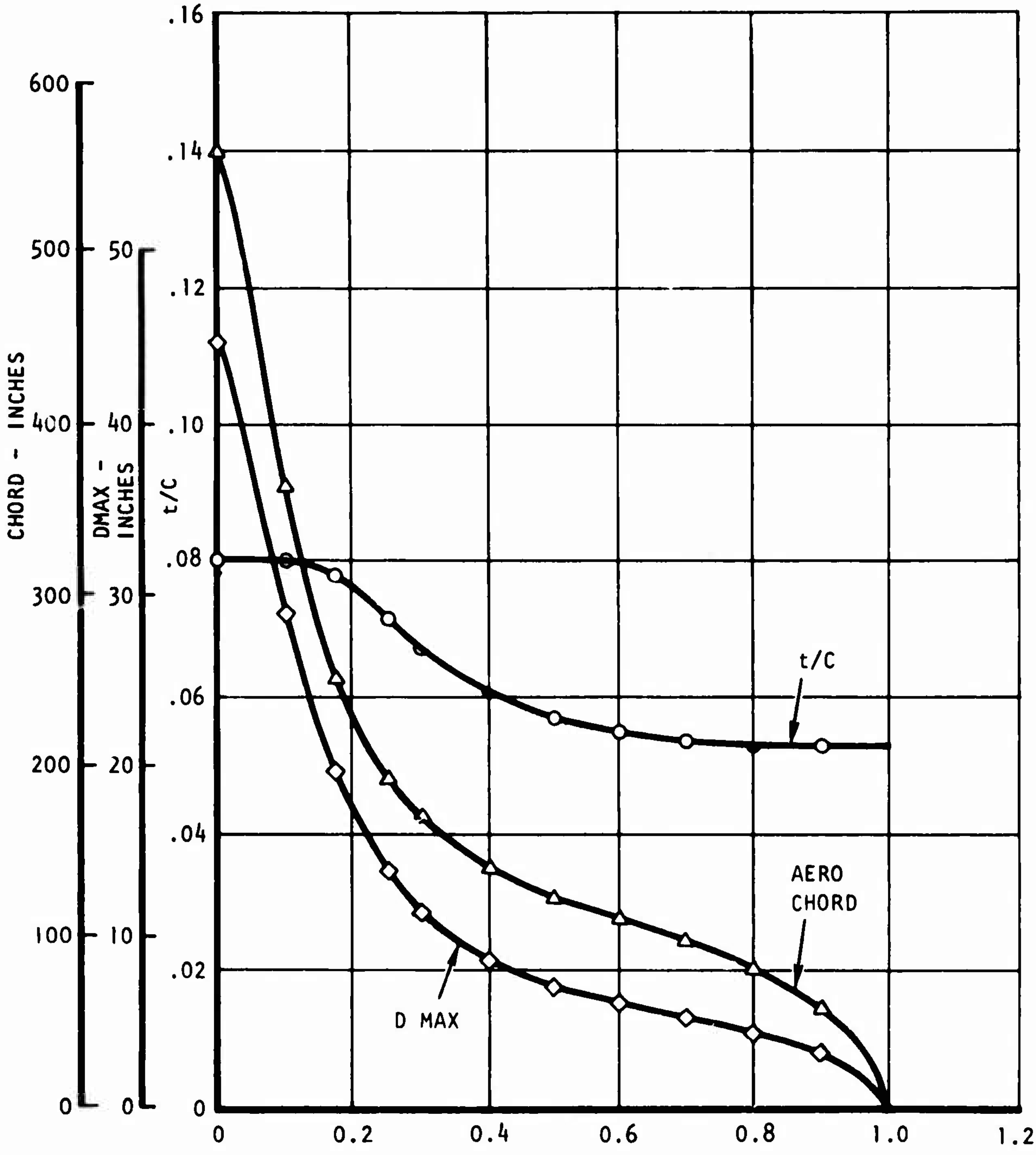


Figure 20. Blended wing normalized geometry.

Different airfoils can also be specified at one to four spanwise control points. The airfoil cross sections are specified in the input data set by code numbers which determine the type of airfoil to be used and the form in which the normalized ordinate data are to be evaluated. One set of codes provides for evaluation of local chordwise depths with a polynomial equation, while the other set directs the evaluation routine to evaluate local chordwise depths from a table of normalized depths versus reference chord locations. Polynomial coefficients for six types of airfoils are stored in the data bank of SWEEP. These coefficients are used for evaluation of local airfoil depths using the following equation:

$$Z_i = \left[aX_i^6 + bX_i^5 + cX_i^4 + dX_i^3 + eX_i^2 + fX_i\right]^{1/2} \qquad (7)$$

Where

a, b, c, d, e, and f = polynomial coefficients

X_i = fraction of chord at which normalized depth is to be evaluated

The true local depth is then determined by:

$$D_i = Z_i \times D_{max_i} \qquad (8)$$

The tabulated data in Table 27, are the airfoil depth data used to determine the coefficients found in Table 26. The data set in the SWEEP data bank for the second method of defining airfoil cross sections is similar to the tabulated data. Provisions are made for table data, with up to 48 chord points for five different airfoils. Depths between chord control points are determined by straight-line interpolation of ordinates between the control points. Cross-sectional areas of the structural box are determined by numerical integration of depths evaluated at evenly spaced points along the structural chord.

Variable-sweep surfaces (Figure 21) are defined for the forward design sweep position. The design data modules of SWEEP evaluate the various swept geometries, compute the design gross airloads at compatible stations at each position, and order the proper data for the wing weight evaluation.

The pivot location is specified by the general method of defining a point on the wing planform. The axis of rotation for the movable panel is assumed to be normal to the XY-plane at the defined pivot point. The theoretical

planform geometry of the surface with the movable panel at any swept position is based on (1) the extension of movable panel leading and trailing edge lines to the vehicle centerline and (2) the rotated position of the points defined by the intersection of the structural reference line and the theoretical tip chord. Rotated position coordinates for the control points computed from the geometric relationships of a line of finite length L, rotated $\pm\Lambda$ degrees, L being the distance between the pivot point and the control point.

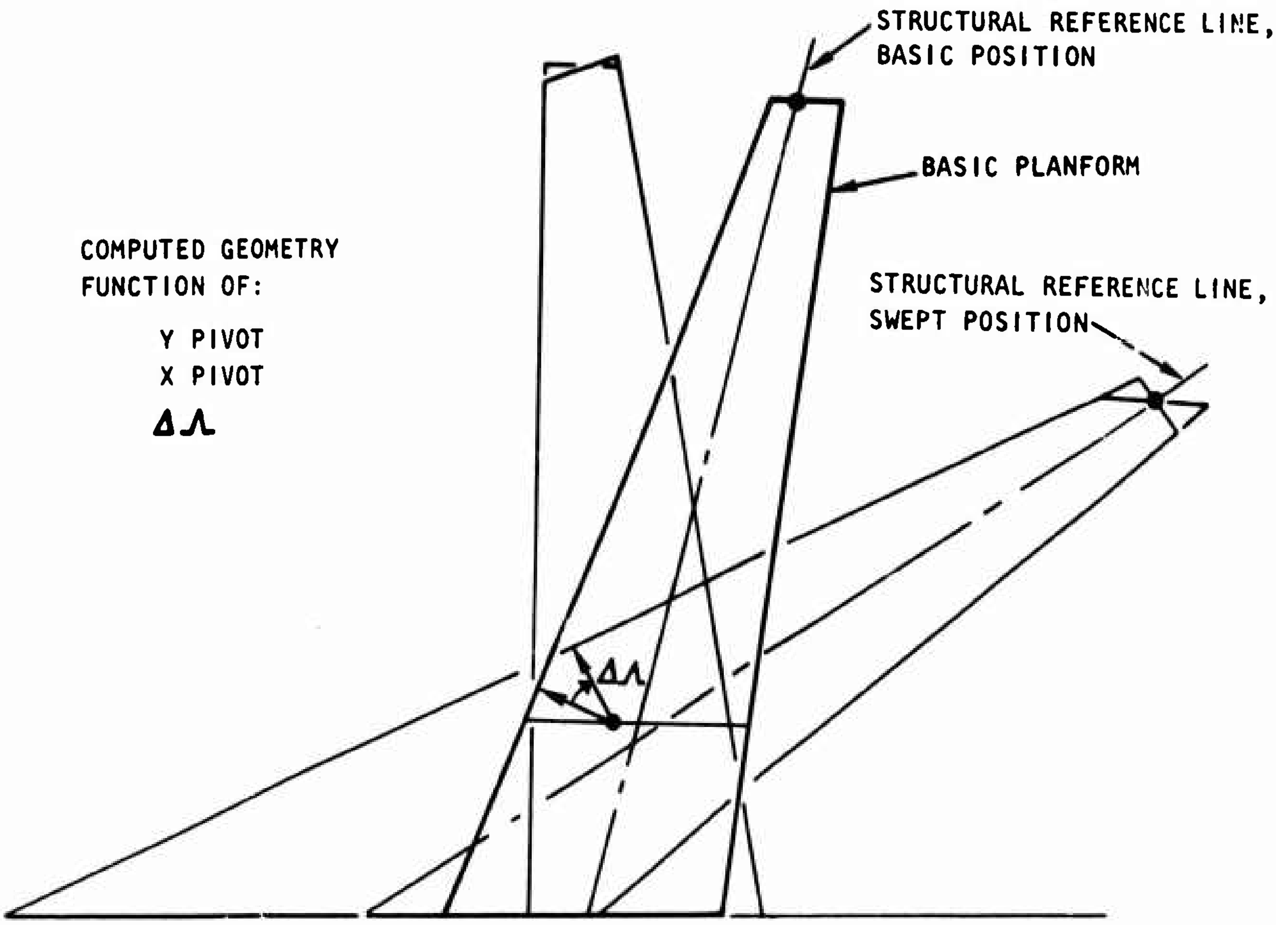


Figure 21. Variable-sweep wing geometry idealization.

LIFTING SURFACE DESIGN DATA

Design data for the structural synthesis of the torque box of lifting surfaces are developed first in the design data development modules of SWEEP, and final data are evaluated by special analysis routines in the wing and empennage weight estimation module. Design loads, flutter stiffness requirements, and material properties data are ordered to conform to the data requirements for the synthesis and weight analysis section.

Six data calculation/data processing functions are performed in this section:

1. Leading and trailing edge structure weight and weight distribution estimation, overlay (14,0)
2. Fuel, wing contents, and external concentrated deadweight and weight distribution estimation, overlay (15,0)
3. Flutter stiffness requirements estimation, overlay (16,0)
4. Design airloads data process, overlay (16,0)
5. Material properties data process, overlay (16,0)
6. Initial inertia load and couple arm estimation, overlay (16,0)

LEADING AND TRAILING EDGE STRUCTURES

Weight estimates for all structures forward of the front spar and aft of the rear spar are made initially to provide weight and weight distribution data for inertia load estimates: shear, bending moment, and torsional moments. The procedures for weight estimation of these fixed structures and control surface devices are discussed under "Weight Analysis," in this section.

Each major structural component of the leading and trailing edge is processed separately so that local effects of these structures are reflected in the design loads. Component as well as strip panel weight centers of gravity and weight moments of inertia are estimated using a finite grid, numerical integration procedure. The grid pattern consists of aerodynamic strips and spanwise cuts, resulting in rectangular grids for which all mass properties characteristics can be evaluated and summation performed to required control points. Figure 22 shows leading edge panel No. 2 with typical chordwise strips, finite grid cuts for strip S_N, and grid NM. Each grid is treated as a rectangular panel of uniform

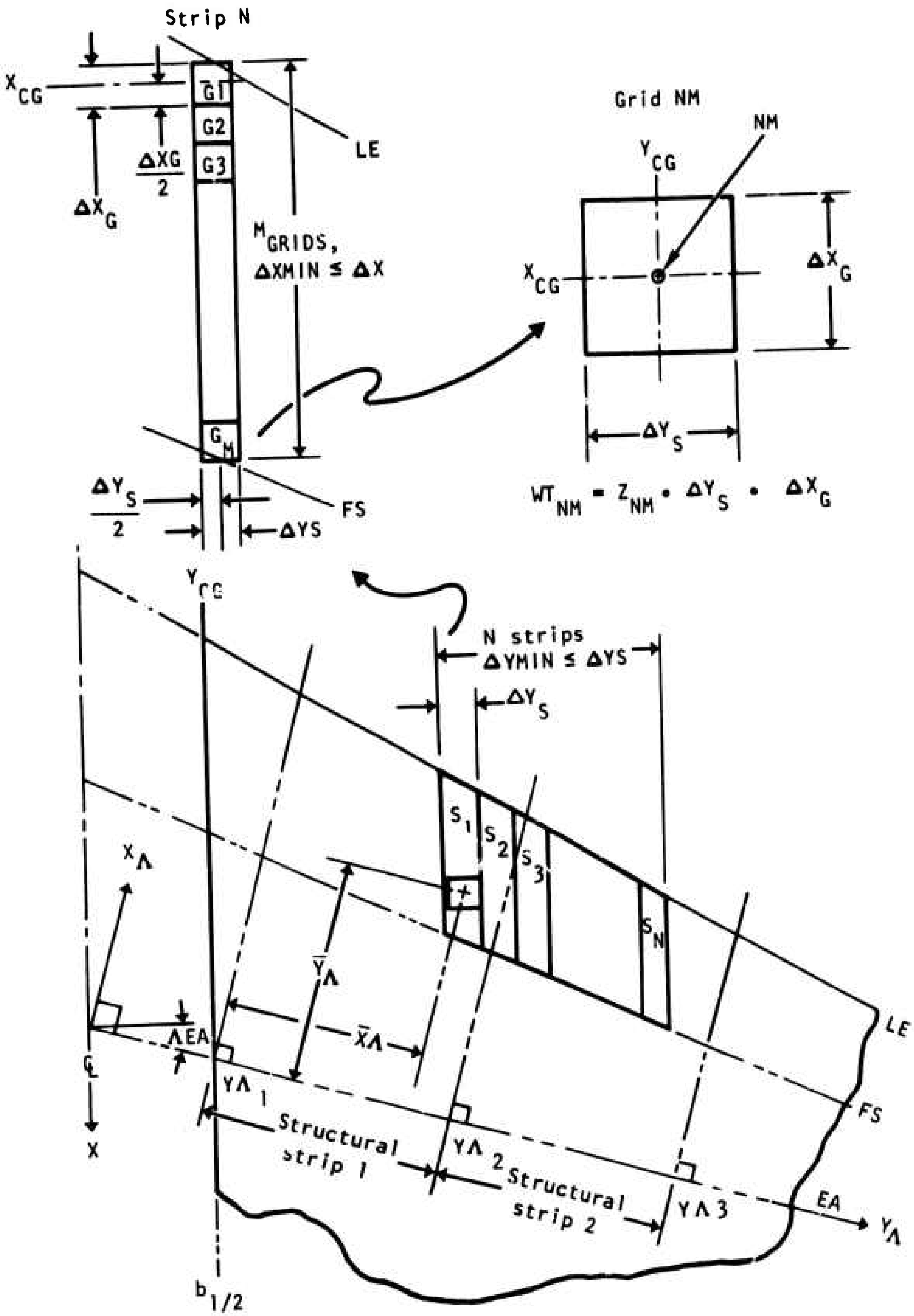


Figure 22. Mass properties integration grid system.

density Z_{NM}, which is dependent upon the location of the centroid of the grid within the panel. Pitch (I_{Yo}), roll (I_{Xo}), and yaw (I_{Zo}) moments of inertia of the grid about its centroid are computed from:

$$I_{Yo} = W_{NM}\left[\frac{1}{12}(\Delta X_G)^2 + K(D_{NM})^2\right] \tag{9a}$$

$$I_{Xo} = W_{NM}\left[\frac{1}{12}(\Delta Y_G)^2 + K(D_{NM})^2\right] \tag{9b}$$

$$I_{Zo} = W_{NM}\left[\frac{1}{12}(\Delta X_G)^2 + \frac{1}{12}(\Delta Y_G)^2\right] \tag{9c}$$

Where

D_{NM} = airfoil depth at grid centroid

K = inertia factor for mass distribution along Z-axis

The integration of weight, moments, and inertia for the structural reference system defined by Y_Λ and X_Λ depends upon the grid centroid coordinates and the structural strip boundary lines defined by lines normal to the Y_Λ reference axis through the structural control points $Y_{\Lambda i}$. All grid mass properties within a strip are summed at the inboard control station. Pitch and roll I_o's are rotated into the structural system with the rotational equations:

$$I_{Yos} = I_{Yo}\, Cos^2\Lambda_{EA} + I_{Xo} Sin^2\Lambda_{EA} \tag{10a}$$

$$I_{Xos} = I_{Xo}\, Cos^2\Lambda_{EA} + I_{Yo} Sin^2\Lambda_{EA} \tag{10b}$$

The grid moments about each control station are determined by calculating the normal distances between the grid centroids and the structural references axis, $\overline{Y}_\Lambda$ and $\overline{X}_\Lambda$. Total strip weights and moments are processed into shears and moments at each control station for later use in estimation of 1g inertia loads.

The weight evaluation routines for leading and trailing edge structures order geometry, weight, and weight distribution data for fixed structures and each defined control device. Provisions are made for three sets of leading edge devices and six sets of trailing edge devices - two spoiler types, three flap types, and one aileron/flap type. Each device is bounded by defined Y and X control lines - inboard and outboard, forward and aft.

These data are checked by the strip/grid generator and integration routine to logically include or bypass control device evaluation. In the event a strip or grid boundary straddles a control device boundary, a weight correction density factor at that strip or grid is computed based on the ratio of that part of the device within the strip/grid to the strip/grid dimensions. The adjusted weight is then assumed to be distributed uniformly over the complete strip/grid. The minor errors resulting from this condition are assumed to be within the accuracy of the analysis and, in some cases, counteracted by the existence of inboard and outboard substrips and forward and aft subgrids.

Control devices added to leading and trailing edges generally replace fixed structure, except for devices like kruger flaps and spoilers. Deletion of and/or adjustment of fixed structure weight distributions within the boundaries of the particular device is made by the integration routine based on the type of device indicators and data sets created to define the boundaries of fixed structure to be deleted or adjusted. Figure 23 shows a typical example of chordwise distribution at a leading edge section. If the control device is a kruger flap, as shown, three weight distribution sets are created - two positive sets for the basic fixed leading edge and kruger flap, and a negative set for deletion of portions of the fixed structure.

Straight-line, trapezoidal weight distribution surfaces are assumed for all leading and trailing edge structures along the aerodynamic chord to define variations in unit distribution, as shown in Figure 24, and between primary spanwise control stations to define spanwise weight-per-inch distributions. The area under each weight distribution line is equal to the assumed weight, the ordinates being controlled by preprogrammed (but adjustable with data in the input data set) distribution taper ratios. Given panel weight, W_p, taper ratio, λ_p, panel span, ΔY_p, and inboard panel boundary station, $Y_{P_{IB}}$, the surface distribution can be reduced to straight-line equation form, referenced to the X, Y, Z aerodynamic coordinate system, using trapezoidal geometric properties. The unit weight, Z_p, at any station Y can be evaluated with Equation 1 as:

$$Z_{P_i} = A_p Y_i + C_p \tag{11a}$$

$$C_p = Z_{PIB} - A_p Y_{PIB}$$

$$Z_{PIB} = \frac{2W_p}{\Delta Y_p\ (1 + \lambda_p)} \tag{11b}$$

$$Z_{P\O B} = \lambda_p\ Z_{PIB} \tag{11c}$$

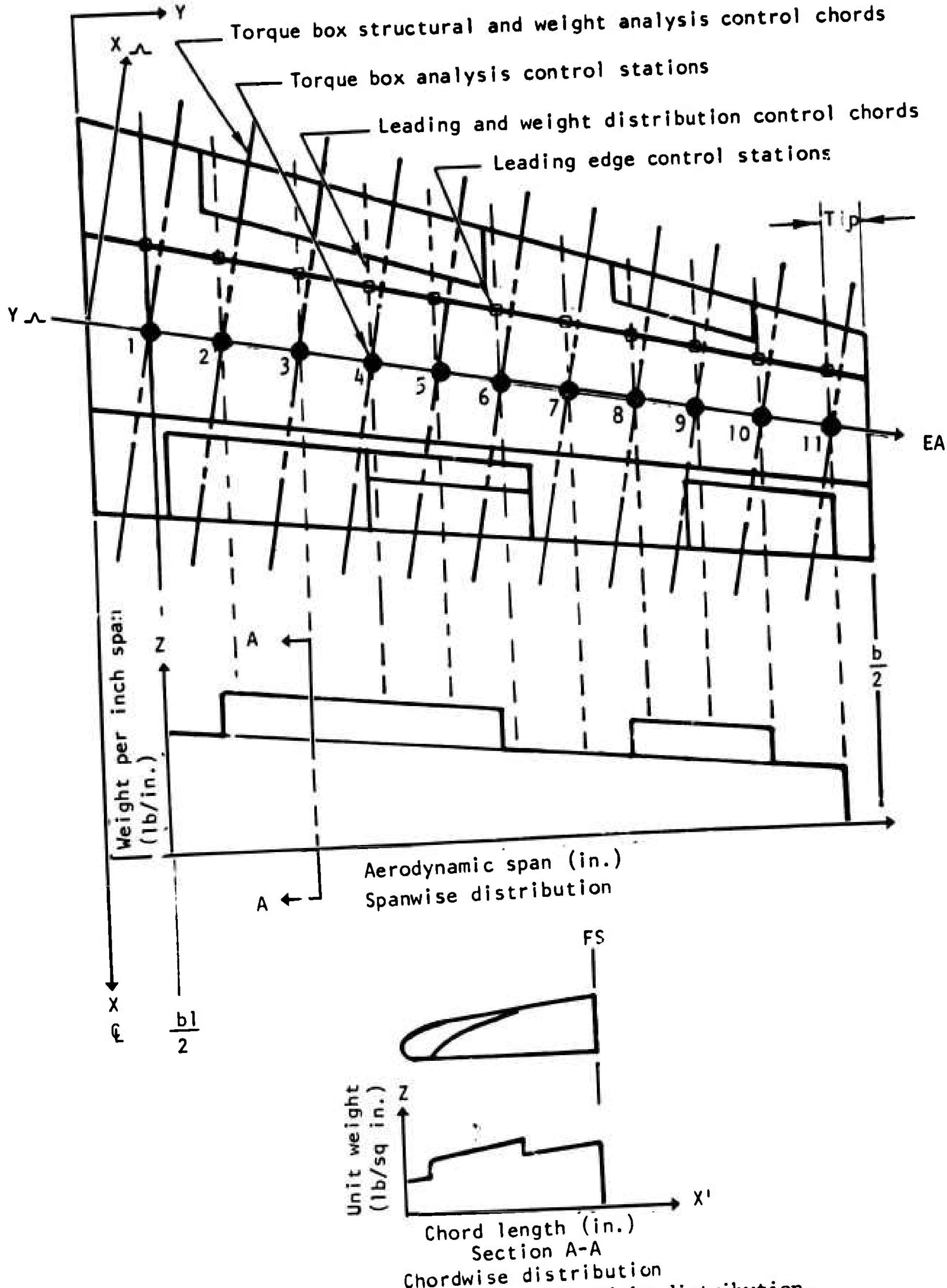


Figure 23. Leading edge structure weight distribution.

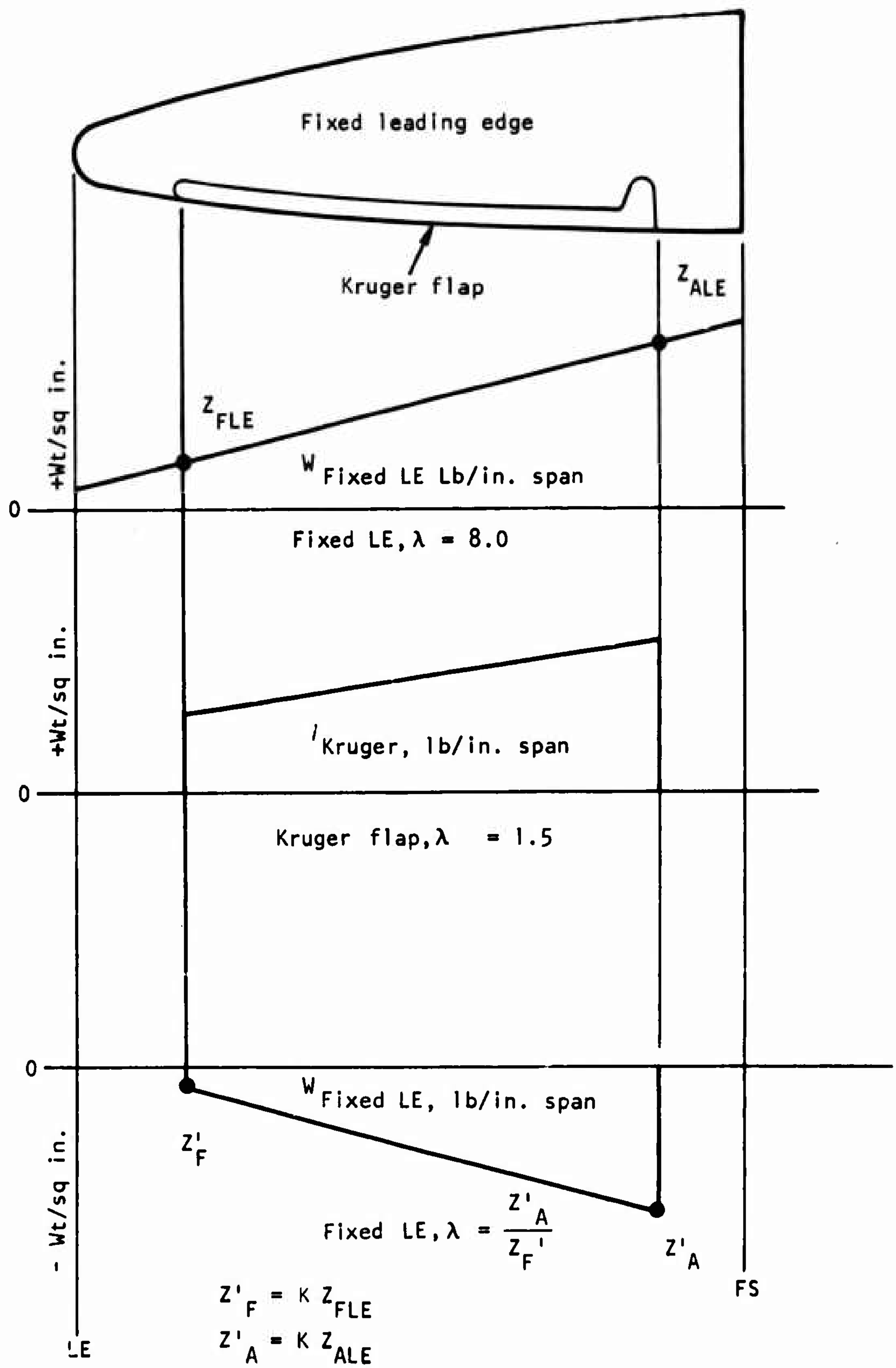


Figure 24. Leading edge structure chordwise weight distribution.

Where

A_p and C_p = equation constants

Z_{PIB} and $Z_{P\emptyset B}$ = unit weight ordinate at inboard and outboard stations, respectively

The weight distribution taper ratio for spanwise distributions is always treated as the ratio of the outboard ordinate to the inboard ordinate. For chordwise distributions, the taper ratio is always treated as the ratio of the aft ordinate to the forward ordinate.

Integration of trailing edge distributions requires additional data to process spoiler/flap configurations shown in Figure 25. Although the procedures are the same as for the leading edges, indicators and factors are required for the processing logic to (1) sense the combination in order to prevent deletion of fixed trailing edge weights twice (first for spoilers, and second for flaps) and (2) account for increased fixed upper and lower trailing edge structures forward of the devices.

Total flap weights are estimated as the sum of flap panel and flap supports and carriages. As indicated in Figure 25, this weight is proportioned and distributed separately. Panel weights are distributed between the flap leading edge and trailing edge, while supports and carriages are distributed between the rear spar and $X_{SUPT\ AFT}$. This aft support distribution point depends upon the type of flap configuration (simple, single-slotted, double-slotted, or triple-slotted), the aft-most panel chord, and the leading edge coordinate of this panel. The incremental distance of the coordinate point aft of the panel leading edge is preset at a fraction of the panel chord. This assumed factor also depends upon the flap type and can be changed with data in the input data set.

NONSTRUCTURAL WING DEADWEIGHT

Nonstructural wing deadweight items are analyzed for mass properties characteristics by individual subroutines. Weight distribution estimates are made for fuel, fuel systems, surface controls and equipment subsystems, and externally mounted components. The mass properties evaluations for these items are similar to the procedures used for leading and trailing edge structures.

A two-cell fuel containment system is used for wing fuel distribution (Figure 26). Data describing the locations of the fuel cells must be indicated to the program. Fuel is assumed to be distributed between these spanwise stations and the front and rear spars. Eleven evenly spaced

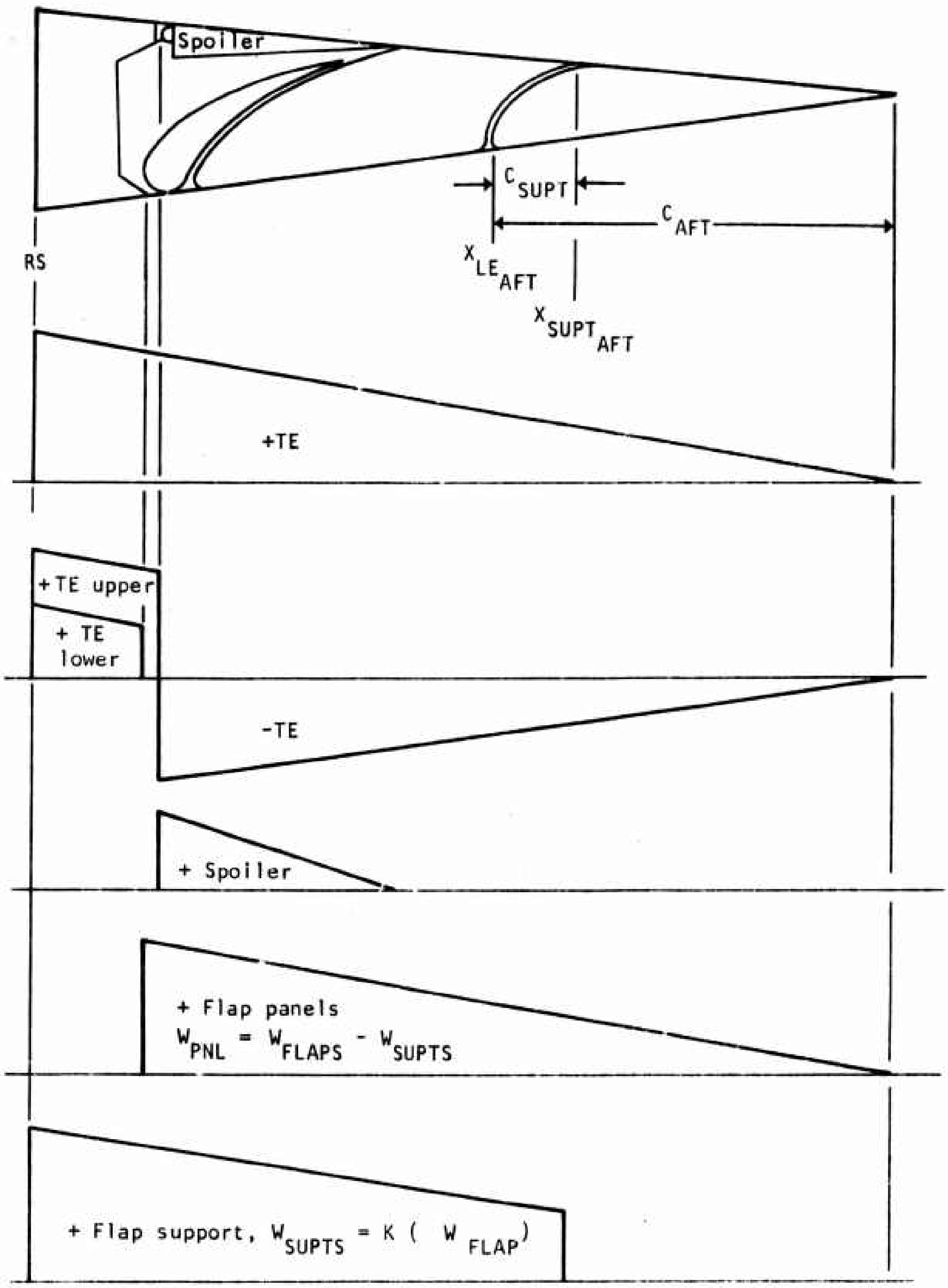


Figure 25. Trailing edge structure chordwise weight distribution.

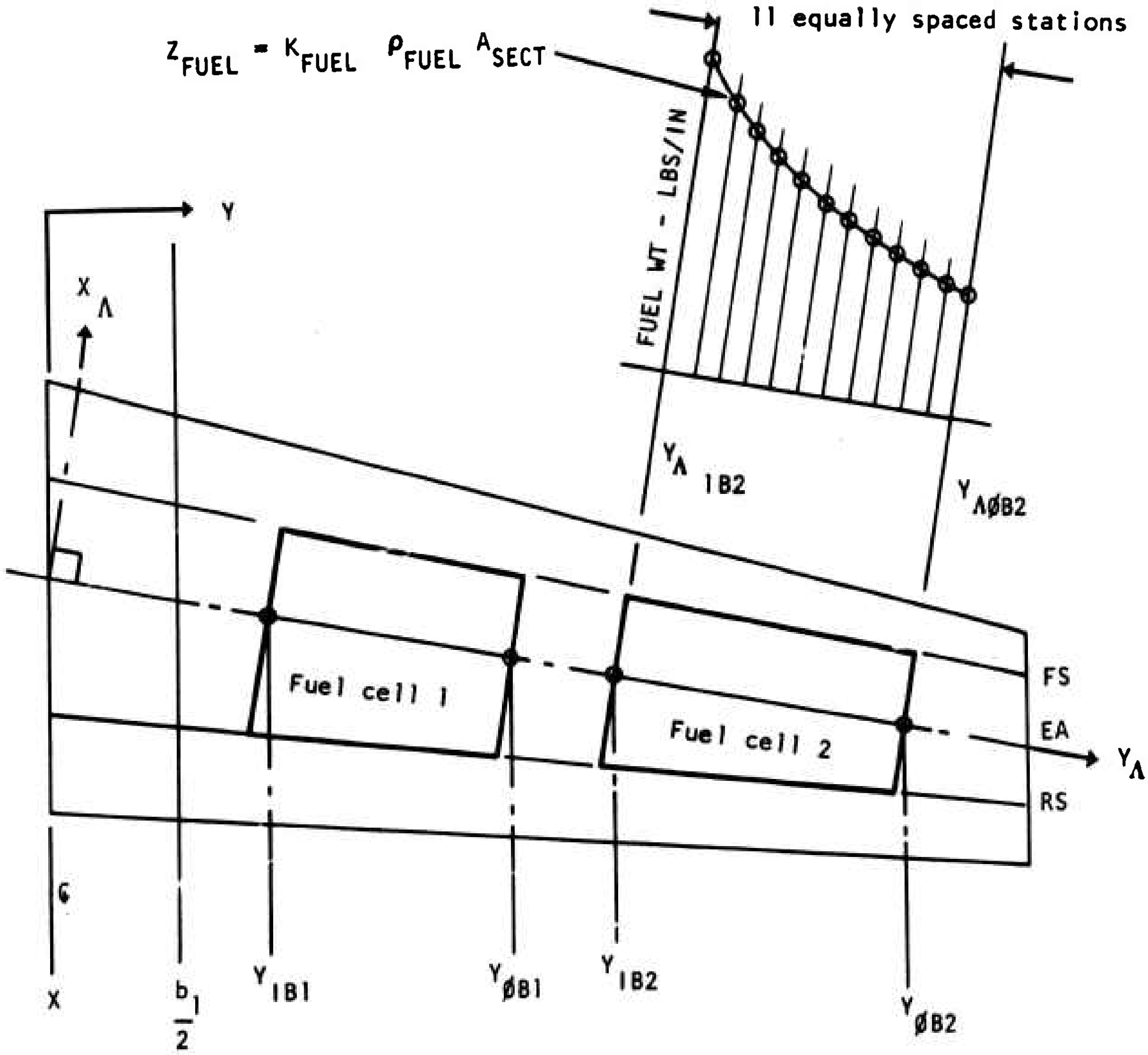


Figure 26. Wing fuel distribution.

distribution control stations are calculated for each cell to be used for volumetric computations, using the equation:

$$\sum W_{fuel} = \sum_{i=1,10} \frac{1}{2} \Delta Y_{fi} \left(Z_{fi} + Z_{fi+1} \right) \tag{12}$$

Where

Z_{fi} = fuel weight at station Y_{fi}

ΔY_{fi} = spanwise distance between the 11 fuel cell control stations

The fuel weight at each control station is first computed from the product of fuel density (assumed as 0.026 pound per cubic inch, based on 6.5 pounds per gallon fuel and in-place volume of 251 cubic inches per gallon) times the torque box cross-sectional area at that station.

The initial volume computed by the program is used as the fuel volume in the cell if the input data set does not contain a specified required volume. However, if the specified volume is larger than the calculated volume, the program estimated volume is used.

Fuel system weights in each fuel cell are assumed to be a fraction of the fuel capacity (assumed value = 0.0223 pound per pound of fuel) and are distributed with the fuel weight. The initial distribution ordinates are corrected for the final required capacity plus the weight of the fuel system by the density correction factor, K_{Fuel}:

$$K_{Fuel} = \frac{W_{required\ capacity} + W_{fuel\ system}}{W_{calculated\ capacity}} \tag{13}$$

Fuel and fuel systems mass properties data are then evaluated for the full-capacity conditions. For fuel levels less than capacity, the fuel weight in each cell is assumed to decrease proportionately over the complete cell. Thus, full-capacity mass properties can be scaled linearly to obtain the desired fuel loading. The scaling factor is derived from Equation 13:

$$K_{Fuel} = \frac{W_{design\ fuel} + W_{fuel\ system}}{W_{required\ capacity} + W_{fuel\ system}} \tag{13a}$$

Mass properties integration of fuel and fuel systems is based on linear spanwise distributions between the 11 control stations and is uniformly distributed along the structural chord. An evaluation routine similar to that described for the leading and trailing edge evaluation is used. The basic reference system, however, is the structural reference system defined by Y_Λ and X_Λ.

This integration routine is also used for both initial and final evaluation of torque box structure mass properties. Initial estimates for torque box weight distributions are programmed as part of the fuel distribution subroutine.

The input data set must include weight and distribution parameters for surface controls and equipment subsystems and externally mounted components. Three types of distribution schemes are provided for subsystems and miscellaneous items: (1) uniform distribution over the planform of the box, (2) spanwise line distributions at two different locations on the planform where the total weight is assumed to be distributed spanwise (weight per inch) and acting at the specified line, and (3) six sets of concentrated weights acting at a given coordinate point (Figure 27).

Up to seven externally mounted components (stores, nacelles, landing gear, etc.) can be described in the data set. Data for these items include weight and X, Y, Z location parameters for the centroid of the mass. These are sufficient for deadweight load analysis. However, for moment of inertia computations, additional data are required, consisting of a data set indicator and inertia properties or geometric data necessary to compute moments of inertia about the mass centroid (Figure 28). Mass properties data are evaluated by these weight distribution routines for each set of internal and external mass items indicated in the input data set.

FLUTTER STIFFNESS REQUIREMENTS

Required structural box stiffness for the prevention of flutter is evaluated by special analysis routines in overlay (16,0) of the module. Subroutines GJCAL and GJSI are used for prediction of required stiffness of conventional surfaces, while subroutine GJTT, under control of GJCAL, is used for T-tail vertical tail analysis. The programmed procedures are based on the methods discussed in Volume IV, "Material Properties, Structure Temperature, Flutter and Fatigue."

The equations presented in Volume IV are used to predict required torque box stiffness distributions along the structural span. The evaluation procedure results in estimates of torque box stiffness levels, GJ, at the 11 structural analysis stations. These stiffness levels are treated

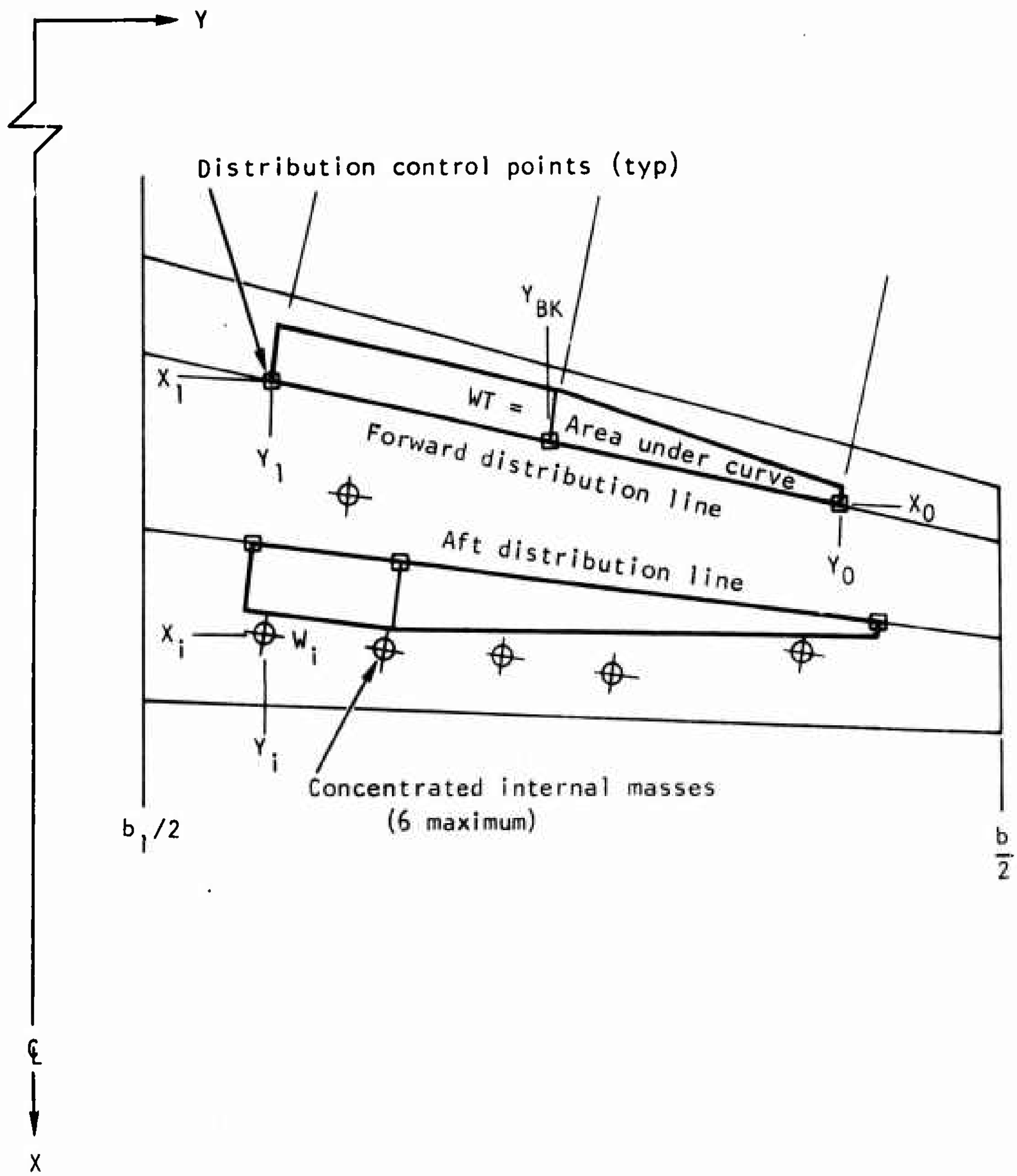


Figure 27. Contents weight distribution.

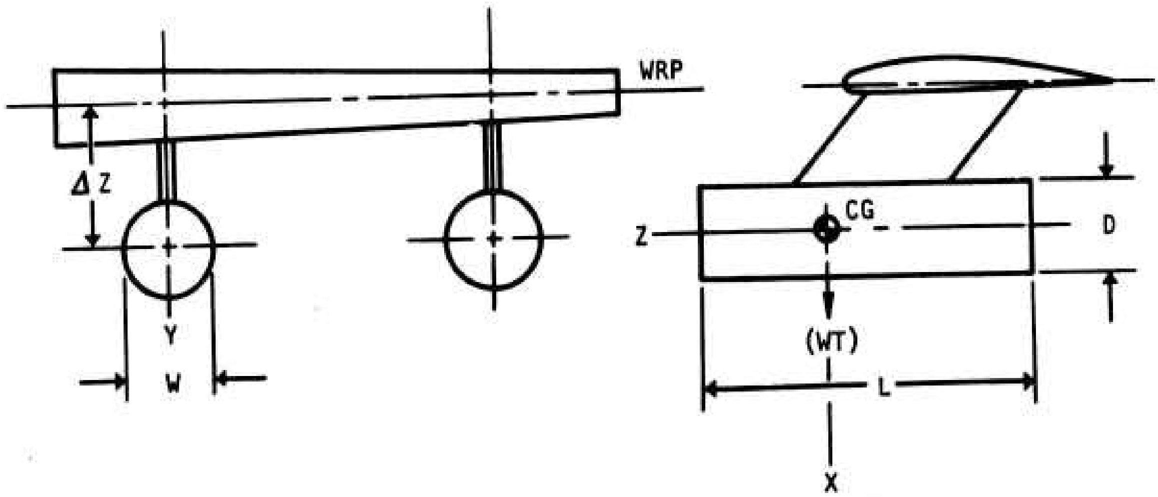


Figure 28. Externally mounted component description.

as minimum design requirements by the structural synthesis/weight analysis routines of the module. The data processing logic is programmed to allow for the use of input required stiffness levels in lieu of computed requirements.

The prediction equations used for conventional surfaces are an integrated form of Equation 17, Volume IV. The programmed equation for determining required GJ_i at any structural station $Y_{\Lambda i}$ has the form:

$$GJ_i = K_{ee} \cdot K_{swp} \cdot K_{geomi} \left[C_1 V_{1i} + C_2 V_{2i} + C_3 V_{3i}\right] \tag{14}$$

Where

K_{ee} and K_{swp} = general planform geometry and critical speed-related expirical factors

C_1, C_2, and C_3 = collected torque box geometry-related constants

K_{geomi}, V_{1i}, V_{2i}, and V_{3i} = collected local torque box geometry related variables

Definitions for the preceding terms are:

$$K_{ee} = \frac{-1.116 K_q Q'}{1{,}480 \left[1 + \frac{0.8}{AR}\right]^2} \tag{14a}$$

$$K_{swp} = \ell^2 \left[0.4 + 0.7 \cos\left(\Lambda ea - 10°\right)\right] \tag{14b}$$

$$K_{geomi} = \left[\frac{C_{RS}' T^2}{3(1 - \lambda')}\right]\left[\frac{W_i D_i}{W_i + D_i}\right] \tag{14c}$$

$$C_1 = \frac{(1 - \lambda')^3}{\left[3(1 - \lambda'\sigma')^3\right]\left[AC(1 - \lambda'\sigma')(t/c)'\right]} \tag{14d}$$

$$C_2 = \frac{1}{\left[(1 - \lambda')(RS - FS)\perp\right]} \tag{14e}$$

$$C_3 = \left[\frac{-\theta_T}{(\theta_R - \theta_T)}\right] \left[\frac{\mathrm{Ln}(\lambda'\sigma')}{AC\ (1 - \lambda'\sigma')\ (t/c)'} + \frac{\mathrm{Ln}(\lambda')}{(1 - \lambda')\ (RS - FS)\perp}\right] \quad (14f)$$

$$V_{1i} = (\lambda'\sigma')^3 + \left[\frac{Di}{D'_R}\right]^3 \left[3\mathrm{Ln}\left(\frac{Di}{\lambda'\sigma' D_{R'}}\right) - 1\right]$$

$$+ \left\{\frac{9\lambda'\ (1 - \sigma')}{2(1 - \lambda')}\right\} \left\{(\lambda'\sigma')^2 + \left[\frac{Di}{D'_R}\right]^2 \left[2\mathrm{Ln}\left(\frac{Di}{\lambda'\sigma' D_{R'}}\right) - 1\right]\right\} \quad (14g)$$

$$+ \left\{\frac{9\lambda'^2\ (1 - \sigma')^2}{(1 - \lambda')^2}\right\} \left\{(\lambda'\sigma') + \left[\frac{Di}{D'_R}\right] \left[\mathrm{Ln}\left(\frac{Di}{\lambda'\sigma' D'_R}\right) - 1\right]\right\}$$

$$V_{2i} = \left[\frac{Ci}{C'_R}\right]^3 \left[\mathrm{Ln}\left(\frac{Ci}{\lambda' C'_R}\right) - \frac{1}{3}\right] + \left[\frac{\lambda'^3}{3}\right] \quad (14h)$$

$$V_{3i} = \left[\left(\frac{Ci}{C'_R}\right)^3 - \lambda'^3\right]$$

where

Q' = effective dynamic pressure at the critical flutter speed, lb/sq ft

AR = planform aspect ratio

Kq = 24.75 Ksp^2, Ksp = flutter speed margin of safety - 1.15 for military, and 1.2 for commercial designs

ℓ = length of exposed span measured along structure axis, in.

Λea = sweep angle of structural axis, deg

C_{RS}' = structural chord as root station, in.

T = rotational factor to convert aerodynamic chords to structural chords, (C_S/c)

W_i = structural width of torque box at any spanwise station $Y_{\Lambda i}$, in.

D_i = average structural depth of torque box at any spanwise station $Y_{\Lambda i}$, in.

λ' = taper ratio of exposed planform, (C_T/C_R')

σ' = thickness ratio taper of exposed span, $(t/c)_{tip}/(t/c)'$

$(t/c)'$ = thickness ratio at exposed root chord

AC = arc centroid of torque box section normal to structural axis, assumed to be equal to torque box cross-sectional area divided by width.

$(RS\text{-}FS)_1$ = width of structural box expressed as a fraction of structural chord C_S

θ_T = angle of twist at tip station, preset to 1 radian

θ_R = angle of twist at exposed root station, preset to 0 radian

D_R' = average structural depth of torque box as exposed root station, in.

C_i' = aerodynamic chord at any spanwise station $Y_{\Lambda i}$, in.

C_R' = aerodynamic chord at exposed root station, in.

The application of Equation 14 to transonic and supersonic designs is discussed in Volume IV, Part 2, Section II, under "Lifting Surface Flutter Methodology." The parameter Q' in Equation 14a reflects the compressibility corrections derived from the methods discussed. The determination of the critical speed/altitude point for flutter is made by subroutine WHVQQ overlay (3,0). This subroutine computes design values for Q', critical speed, critical altitude, and flutter design temperature. The flutter speed margin of safety, K_{SP}, is used to determine the design values. Thus, if the values computed by WHVQQ are used, the K_{SP} value used in subroutine CJCAL is set to 1.0. If the option of directly specifying design values through the surface input data deck is used, the user must select the critical flutter point and input appropriate values for the design Q' and speed margin, since subroutine GJCAL will compute K_{ee}, as shown in Equation 14a.

A modified form of Equation 53 in Volume IV, Part 2, Section II, is used for estimation of T-tail vertical tail flutter requirements. The programmed equation is the same, except for the addition of a scaling factor, K_{VTT}:

$$GJ = \frac{K_{VTT}\, C_{TT}\, e_{et}\, q\, I\psi}{g_o\, C_{ave}^2} \left(\left\lfloor \Delta X_K \right\rfloor \left\{ \frac{S_K}{A_K} \right\} \right) \left\{ \frac{A_K}{S_K} \right\} \tag{15}$$

Where

K_{VTT} = scaling factor, similar to C_{TT}

C_{TT} = model scaling factor derived from Reference 2 as a function of critical flutter speed and horizontal tail dihedral, in.^{6}/lb^2/sec^2

e_{et} = planform geometry parameter, psi

q = dynamic pressure at the critical flutter speed (speed, including flutter margin of safety), psi

$I\psi$ = yaw inertia of horiz   l tail, lb-in.^{2}

g_o = acceleration constant, in./sec^2

C_{ave} = average chord of vertical tail panel, in.

$\left\lfloor \Delta X_K \right\rfloor$ = row matrix of station intervals between analysis points, in.

$\left\{ \frac{S_K}{A_K} \right\}$ = column matrix of ratio of torque box perimeter to torque box cross-sectional area for Kth panel, computed at midpoint of panel, in.$^{-1}$

The parameters q and K_{VTT} are derived by subroutine WHVQQ for T-tail vertical tails, assuming that the critical flutter design point is at the maximum sea-level limit speed, V_L. The flutter margin of safety, K_{SP}, is either 1.15 or 1.20, as previously noted. The output value of K_{VTT} from subroutine WHVQQ includes the model scaling factor, C_{TT}, and is transmitted to subroutine GJTT in the data cell assigned to K_{VTT}; thus, the assigned value of C_{TT} for use by subroutine GJTT is set to 1.0. However, if the critical speed and dynamic pressure are specified as part of the surface input data set, then subroutine GJTT will compute C_{TT} values, based on the input speed and horizontal tail dihedral. In this case, the

input value of K_{VTT} must be set to 1.0 or to the value compatible with the flutter design q, K_{SP}, and/or a preselected flutter equation calibration factor.

Design values of GJ for horizontal tails, conventional vertical tails, and fixed wing surfaces are based on evaluation of Equation 14 at the single critical flutter speed. For variable-sweep wing and T-tail vertical tails, design GJ is based on composite requirement curves. In the variable-sweep analysis, required GJ values are computed for the movable planform in two positions. In T-tail vertical tail, required GJ values are first computed by using Equation 15 and then using Equation 14, the latter based on treating the vertical tail panel as a conventional surface.

In the two aforementioned designs, the selected design values are based on the larger of two structure J-values derived by using Equation 16.

$$J \text{ required} = \frac{(GJ) \text{ required}}{G \text{ material at critical flutter point}} \tag{16}$$

The logic programmed in the synthesis of metallic torque box designs assumes that the section stiffness must be equal to, or larger than, the values specified. Torsional stiffness requirements are transmitted to these routines as required GJ values along with the value of G to be used. In advanced composite structures, the corresponding design temperature is also specified. The temperature is used to develop temperature material property parameters to be used to compute laminate stiffness characteristics, a function of the number of 0°, 45°, and 90° plies in each web. The stiffness requirement synthesis logic for advanced composite structures is programmed to insure that available section GJ is equal to, or greater than, required GJ.

DESIGN AIRLOADS

Design airloads for the torque box structural synthesis are computed by the airloads module of SWEEP. Shears, bending moments, and torsional moments are stored on mass storage files, and are ordered for use by the lifting surface loads routine and processed for the synthesis routines. These loads are integrated in the structural coordinate system.

Provisions are made to rotate and translate the design loads to the structural synthesis reference line, if the two reference lines are not the same (Figure 29). The moments at the load reference point are first resolved to the synthesis reference coordinate system and then translated to the synthesis reference point in order to derive the correct torsional moment.

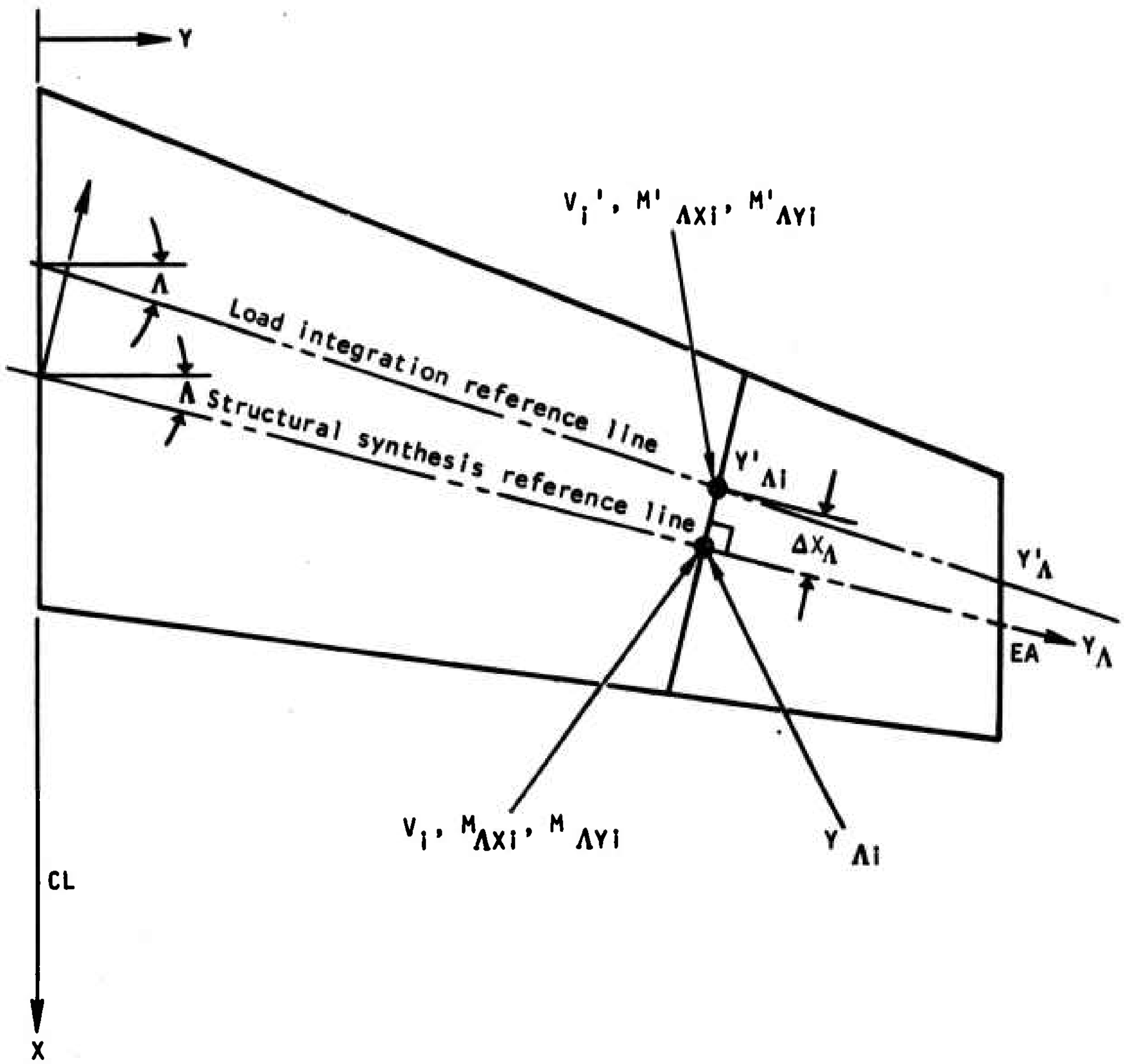


Figure 29. Loads rotation and translation.

$$V_{\Lambda i} = V'_{\Lambda i} \tag{17a}$$

$$M_{X\Lambda i} = \cos \Lambda_{EA} \left[M'_{X\Lambda} \cos \Lambda_{LD} + M'_{Y\Lambda} \sin \Lambda_{LD} \right]$$

$$- \sin \Lambda_{EA} \left[M'_{Y\Lambda} \cos \Lambda_{LD} - M'_{X\Lambda} \sin \Lambda_{LD} \right] \tag{17b}$$

$$M_{Y\Lambda oi} = \cos \Lambda_{EA} \left[M'_{Y\Lambda} \cos \Lambda_{LD} - M'_{X\Lambda} \sin \Lambda_{LD} \right]$$

$$+ \sin \Lambda_{EA} \left[M'_{X\Lambda} \cos \Lambda_{LD} + M'_{Y\Lambda} \sin \Lambda_{LD} \right] \tag{17c}$$

$$M_{Y\Lambda i} = M_{Y\Lambda oi} + \Delta X_{\Lambda} V_{\Lambda i} \tag{17d}$$

Where

$V_{\Lambda i}$ and $V'_{\Lambda i}$ = shears in synthesis and load reference system

$M_{X\Lambda}$ and $M_{X\Lambda}'$ = bending moments in synthesis and load reference system

$M_{Y\Lambda}$ and $M'_{Y\Lambda}$ = torsional moments in synthesis and load reference system

Λ_{EA} and Λ_{LD} = sweep of synthesis and load reference lines

$\Delta\Lambda X$ = distance from synthesis reference point to load reference point measured along structural chord, positive forward, negative aft

MATERIAL PROPERTIES

The structural synthesis of metallic torque box designs require a continuous description of the stress-stain properties of the compression material as well as other physical and mechanical properties. These material properties data are ordered for the synthesis routines from the material properties data bank of SWEEP. The compression stress-strain characteristics are determined from a curve fit of the stress-strain curve derived from the data bank. A

material property table (consisting of curve fit constants; material density; Poisson's ratio; shear and elastic modulus; compression yield stress; and ultimate tension, bearing, and shear stresses) is created from the data bank for the selected material.

The curve fit of the compression properties provides the necessary data for plate and column stability analysis in both the elastic and plastic regions of the material curve. Figure 30 shows a typical stress-strain curve with derived tangent modulus and allowable plate buckling, b/t, through the yield stress of the material. A curve evaluation routine determines the stress-strain values of strain, tangent modulus, and secant modulus at a given stress level so that allowable plate buckling and column stability moduli can be evaluated, including the effects of plasticity. These are used for local and general stability analysis of synthesized structures.

Single-ply physical and mechanical characteristics are used to describe advanced composite material. Normalized strength and stability parameters are internally computed from input descriptions for unidirectional ultimate allowables, Poisson's ratio, elastic moduli, and shear modulus. These parameters are derived for the assumed laminate system - a balanced symmetrical system consisting of plies oriented 0°, ±45°, and 90° to the direction of axial loads. Stability allowables are determined by the synthesis routines based on finite numbers of plies.

INITIAL INERTIA LOADS AND COUPLE ARM ESTIMATION

Initial estimates of inertia loads are made by summation of 1 g shears and moments computed for:

- Initial torque box weight
- Leading edge structures
- Training edge structures
- Miscellaneous contents
- Design fuel and fuel systems
- Design concentrated mass items

Design fuel shears and moments for both fuel cells are determined from scaling factors determined from vehicle design specification fuel loads computed for each cell by the design data development module or through the input data set, specifying the amount and order by which consumed fuel is to

E = 16,319,000 PSI   G = 6,134,969 PSI
μ = 0.330 ρ = 0.161
FCY = 157 KSI   FTU = 162 KSI
FTY = 157 KSI
FcP = 133 KSI

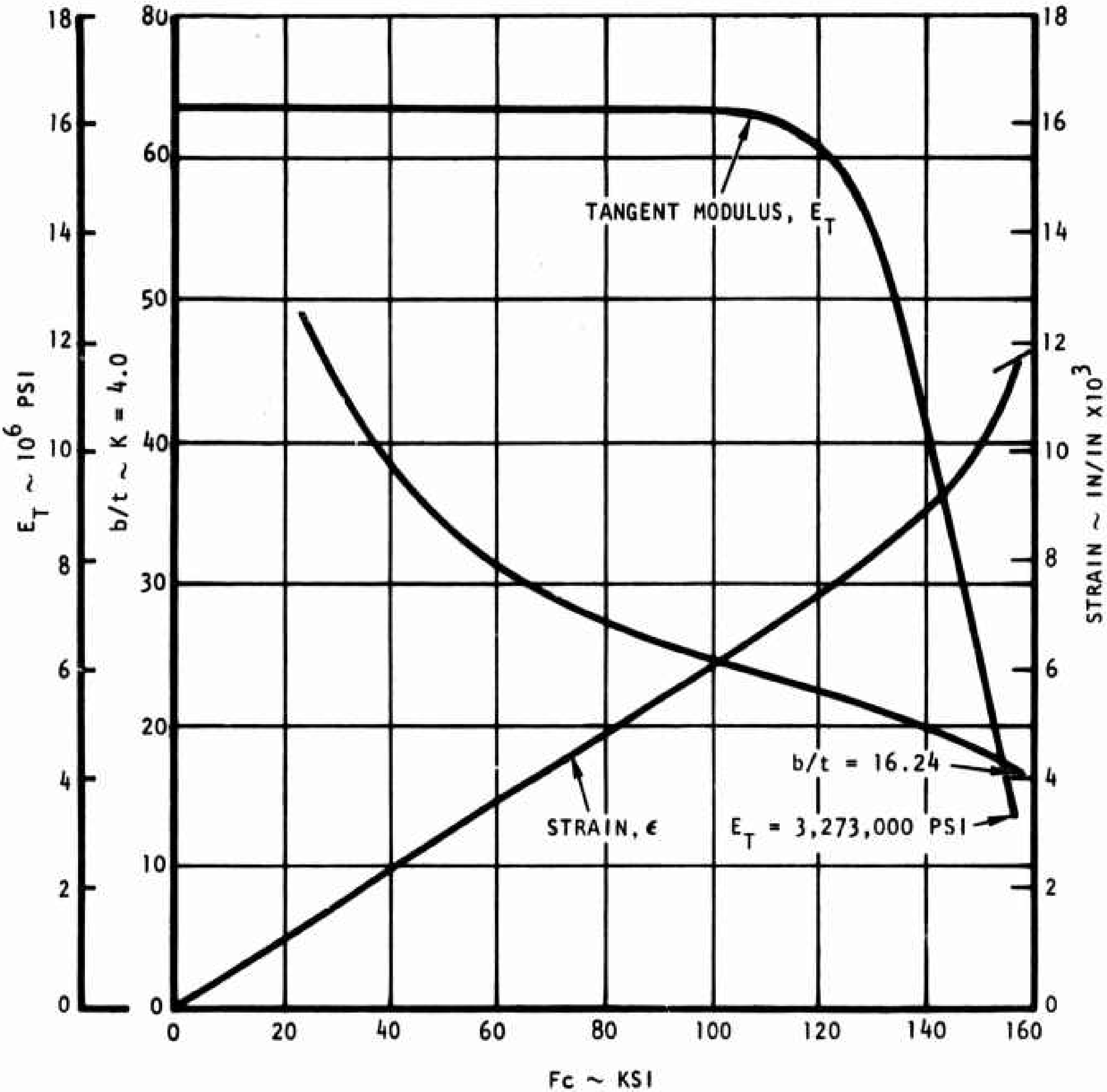


Figure 30. Typical material stress-strain curve and evaluation data.

be expended from each cell. The design concentrated mass items may include fuel or aramament stores which may be expended at the stress design condition. This situation is accounted for through indicators governing the status of the first two external concentrated mass description data sets in the input data set. The shears and moments resulting from these two masses are scaled by the ratio of the remaining-to-inputed values, again, as in the design fuel determination, depending upon the amount and expending indicators. These two indicators determine the order and/or the amount of decrease at each station. The initial torque box shear and moments are separated from other structural items to allow for torque box deadweight changes during the iteration cycle.

Initial couple arms at each station are estimated from the net-ultimate design loads based on the first estimates for inertia loads. Upper- and lower-cover centroids are estimated based on the average load intensity, N_x, and the type of cover construction specified. For multispar construction, the initial centroid is set at 50 percent of the cover $\bar{t}$, determined by assuming maximum allowable compression and tension stresses. The centroids of stringer-stiffened covers are estimated based on preliminary distributions of the available $\bar{t}$ into skin material and stringer geometries. The initial centroids are replaced by calculated cover centroids, adjusted for changes in cover load intensities during the iteration cycles.

STRUCTURAL SYNTHESIS

The lifting surface shear and bending loads are assumed to be reacted by a rectangular cover/spar torque-box structural system acting as a cantelever beam. Bending loads are assumed to be reacted by upper and lower cover couple forces, while the shears are balanced by shear stresses in the front and rear spar webs. With these assumptions, net ultimate design moments at each structural synthesis station are resolved into average load intensities across the structural chord to provide axial load criteria for cover material synthesis.

COVER DESIGN LOADS

The total cover load at any station (i) is determined from:

$$P_{covi} = M_{x\Lambda i}/D_{effi} \tag{18}$$

Where

$M_{x\Lambda i}$ = Net ultimate bending moment

D_{effi} = Effective couple arm of box cover system, determined by subtracting upper and lower cover centroids ($\overline{Y}_u$ and $\overline{Y}_\ell$) from average box depth

The average cover load intensity, Nx (pounds per inch of chord), can then be expressed as

$$N_x = \frac{P_{covi}}{W_{effi}} \tag{19}$$

Where

W_{effi} = Effective cover width available to resist compression or tension loads

Figure 31 pictorially shows the effective cover widths used to determine compression N_x and net tension N_x values. For both covers, effect of front and rear spar caps and skin overhang forward of the front spar plane and aft of the rear spar plane are assumed to be effective as cover t; thus, the effective width takes the form

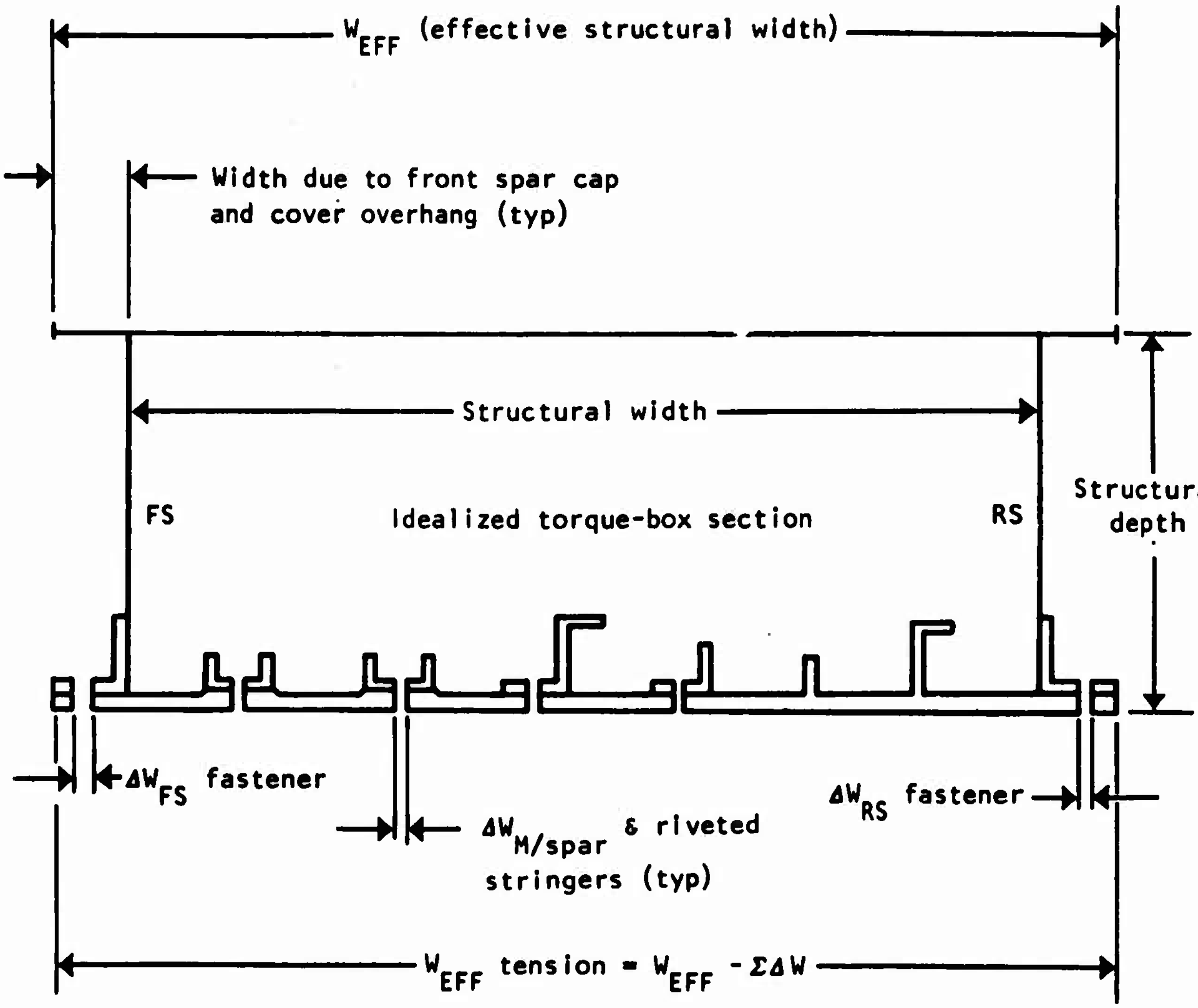


Figure 31. Effective structural width idealization.

$$W_{effi} = W_i + \Delta W_{fwd} + \Delta W_{aft} \tag{20}$$

Equation 19 is used for compression loads. For tension loads, Equation 19 is adjusted for fastener holes at the front and rear spars and for rivet or boltholes for attaching stringers or caps to the cover skins. The cover construction - multispar or stringers (integral or riveted), the number of spars or stringers, and the size of fasteners assumed - determines the incremental width that is subtracted from the results of Equation 19. Thus,

$$W_{effi}\ \text{tension} = W_{effi} - 2S_{FR} - NOS \times S_S \tag{21}$$

Where

S_{FR} = Fasteners diameter at front and rear spars

NOS = Number of intermediate spars for multispar design, number of intermediate riveted stringers, and zero for integrally stiffened cover construction

S_S = Fastener diameter for intermediate stringers or spars.

The synthesis routine determines the load intensity values at each section during each iteration, since the effective couple arm is one of the variables of the analysis. This couple arm effect is sensed by the program and will vary according to load levels, material, construction, and design constraints imposed on the cover synthesis. Under certain conditions, this effect has a pronounced effect on the final design loads and resulting structural weights.

TORQUE-BOX SYNTHESIS

The torque-box synthesis routines are designed to provide cover sizing data that can be integrated to provide estimates of torque-box component weights and weight distributions. Procedures and logic are programmed so that rational weight variation data can be predicted for various materials, constructions, vehicle and structural design criteria and requirements, etc, and reflect imposed constraints of material and/or fabrication minimum gages, and optimum design compromises such as stringer, rib or spar spacings, stringer configurations and geometries, and spanwise stringer or spar orientations. Also, the logic includes an initial synthesis pass to determine sizings required to resist design loads, and a second pass, if necessary to satisfy both stiffness and strength requirements. The synthesis results

provides preliminary sizing and design data which can be used as advanced data by engineering disciplines requiring structural data. Mass distribution data, preliminary stiffness (EI, GJ) distributions, preliminary load levels, preliminary optimum, but practical sizing, operating stress levels, etc, are part of the detail design data resulting from the synthesis of the torque-box structure.

For empennage torque-box synthesis, the procedures are the same as used for the wing box, except that:

1. For the horizontal tail, the compression cover will generally be the lower cover; the tension cover, the upper. Horizontal tail loads are processed by the airloads module so that the cover reacting the maximum compression loads will be treated as the upper cover by the wing and empennage module. The status of the design loads data set is identified by code in XMISC(42).

2. For the vertical tail, both covers are sized to the same requirements, either tension or compression, since airloads can act in either direction. Inertia loads are not considered in design loads calculations for vertical tails.

3. For the vertical tail, the surface planform geometry is generally expressed in terms of one panel.

The program will account for the discrete differences among the various lifting surfaces. The only condition will be to specify the type of surface to be analyzed for the given design condition.

Metallic Torque-Box Analysis

Metallic torque-box designs that can be analyzed include:

1. Skin-stringer multirib designs: riveted Z, integral Z, integral I, and riveted angle (Figure 32)

2. Multispar designs with plate or honeycomb covers (Figure 33)

Support ribs or spars are idealized corrugated web plus cap systems. The front and rear spars are synthesized as flat-plate stiffened designs. Cover material can be any material type that can be described by a stress-strain curve fitting model and for which the elastic and shear moduli and strength cutoff limits can be defined.

The synthesis program requires that local crippling and general stability requirements for plates and columns be expressed in terms of b/t or L/ρ for all stress levels, including the plastic range of the material. Figure 30 shows a typical stress-strain curve with derived E_T and b/t plotted for the full range of allowable stresses. The synthesis procedure first requires that a stress be assumed. From this condition, strain, tangent modulus, and

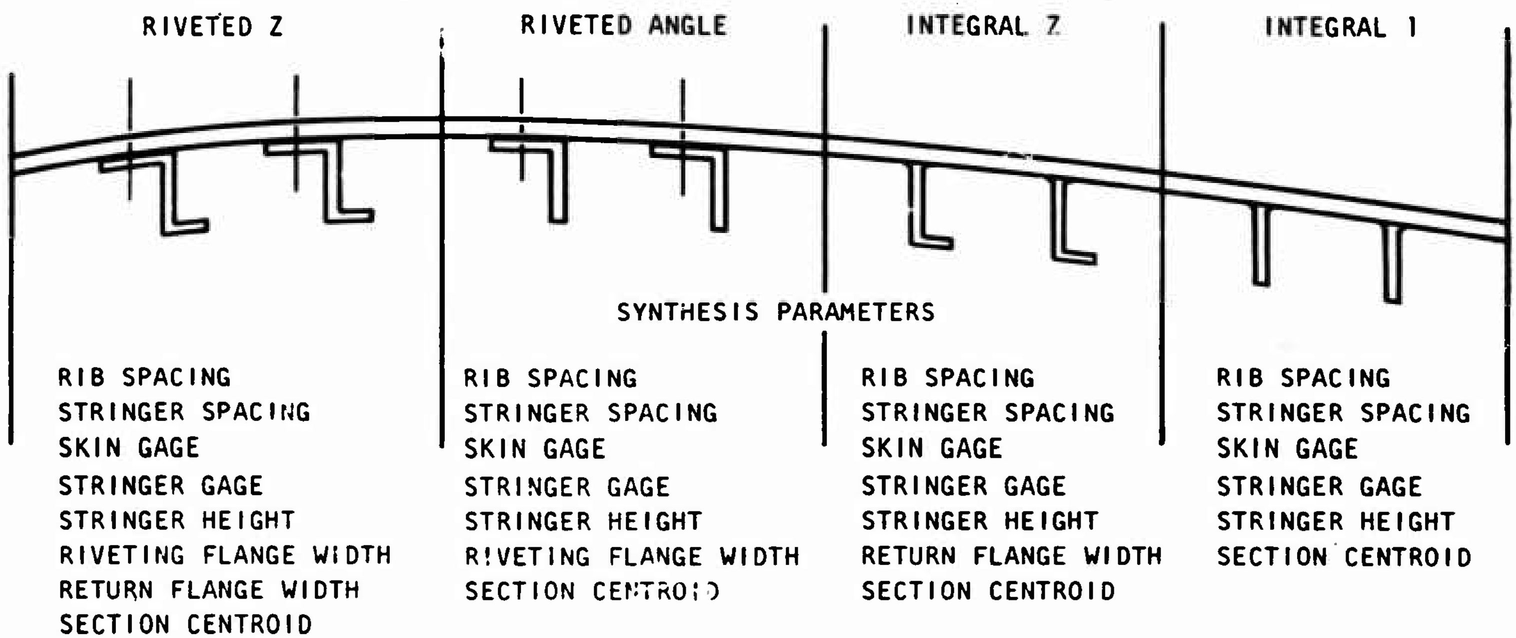


Figure 32. Multirib stringer design options.

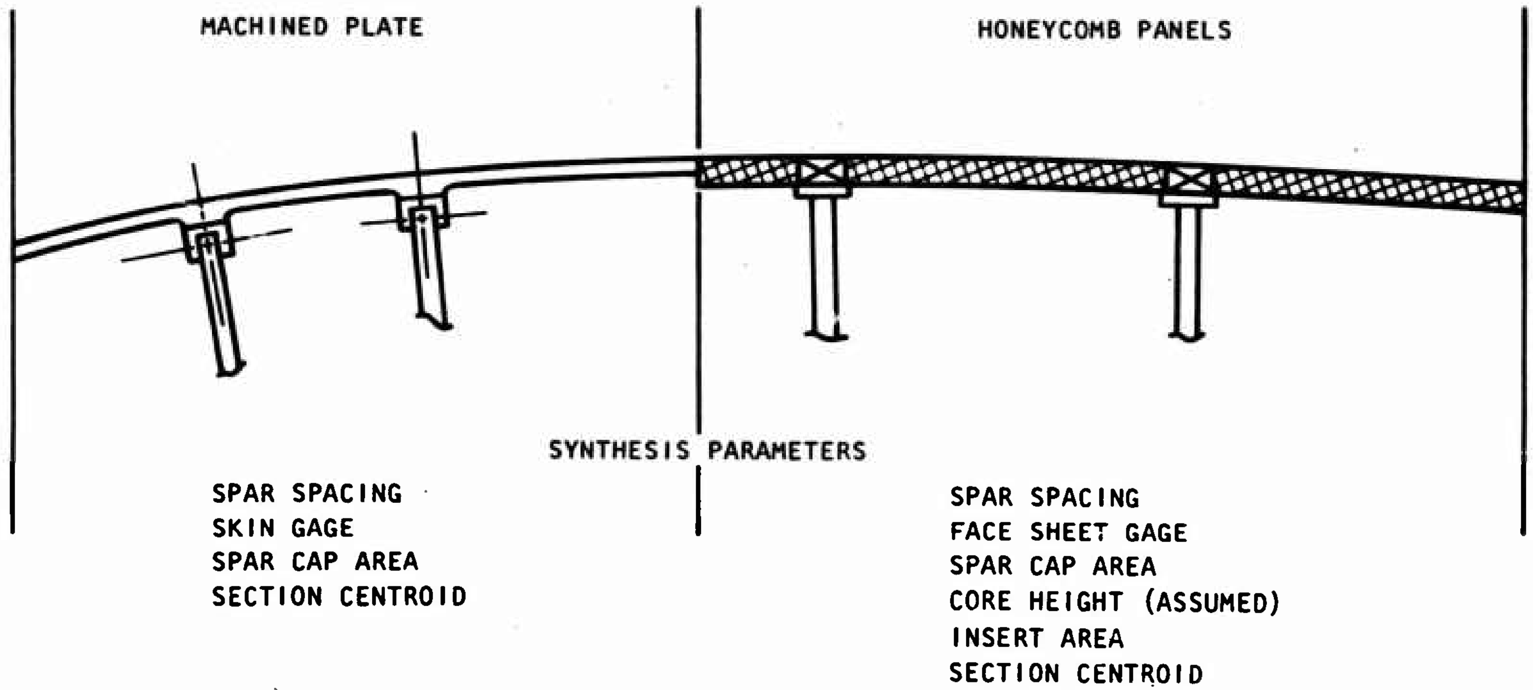


Figure 33. Multispar design options.

secant modulus values can be derived from the curve fit equation; thus, for the given stress level, stability parameters for the plate and column elements can be derived from the equations:

$$b/t = \left[\frac{K\pi^2 E_R}{12\ (1-u^2)\ F_c}\right]^{1/2} \tag{22}$$

for plate buckling and local crippling, and

$$L/\rho = \left[\frac{\pi^2 E_T}{F_c}\right]^{1/2} \tag{23}$$

for general column instability.

K = Buckling coefficients for infinitely long, flat plates, with K = 4.0 for plates simply supported at the edges, and K = 0.426 for plates simply supported at one edge and free at the other

u = Poisson's ratio

F_c = Compression stress level

E_R = Reduced modulus at F_c for long, slender plates, determined as a function of the elastic, tangent, and secant moduli

E_T = Tangent modulus at F_c

Equations 22 and 23 and the ability to evaluate the stress-strain curve through the yield cutoff stress form the basis for the multirib and multispar synthesis procedures.

In stringer-type construction, rib spacing L, stringer spacing b, stringer height h, stringer flanges f, stringer gage ts, and skin gage tsk are synthesized from the effective cover material $\overline{t}$ for the particular stress level. Strength, local, and general instability conditions are satisfied under constraints of minimum gages and minimum or maximum L, b, h, or f. The analysis can also operate unconstrained so that optimum values for L, b, h, f, ts, and tsk can be determined. For stringer-skin edge restraint coupling effects, an added restraint of minimum ratio of ts/tsk is used.

The synthesis search requires three levels of operation. In the first level, stringer spacing is the primary search parameter (Figure 34). The second level search (Figure 35) involves the determination of the optimum operating stress level for the assumed stringer spacing. For each condition of stringer spacing and stress level, the best arrangement skin-stringer geometries are determined through a search process that requires the highest section inertia, Ix, be developed, which results in an allowable rib spacing for the design. For this optimization, constraints of minimum ts/tsk, a rational range of tsk/$\bar{t}$, and limiting ranges of rib spacings are used to control the search within acceptable limits.

In all cases, the primary optimization assumes that cover material can be traded for rib material. Thus, in each search level, $\bar{t}$ total, the sum of $\bar{t}$ covers and $\bar{t}$ ribs can be plotted against the current search parameter, and the optimum value of the search parameter can be obtained for the smallest value of $\bar{t}$ total. The stringer synthesis routine can be controlled to analyze stringer orientation in either constant spacing or constant number of stringer modes.

Figure 32 shows the type of stringer configurations that can be analyzed by the program for the compression cover. The tension cover arrangement will be asssumed to be similar, except that the lower cover $\bar{t}$ will be derived from net section tension requirements or negative loading compression requirements.

The multispar synthesis involves only the synthesis of skin and cap material for specified spar spacings, with selection of the best practical spar spacings or combination of spar spacing made after evaluation of output design and weight data. The synthesis considers the effectiveness of the intermediate spar caps in resisting bending loads. The intermediate spar webs are sized to similar conditions as rib webs, and are assumed to be corrugated webs.

In honeycomb cover constructions, the strength effect of inserts at the spars and the panel thickness effect on cover stability are considered. The ineffective weights of bond and core material plus the inserts are included in the equations for $\bar{t}_{total}$.

Rib and intermediate spar synthesis is based in spring rate requirements for the cover column structure and for induced loads due to cover flexure. The web sizing is expressed in terms of equivalent $\bar{t}$ rib, which is derived from the volume of rib material divided by the section width and rib spacing.

Front and rear spar webs are synthesized as flat stiffened plate structures resisting vertical shears. The actual depths of the airfoil are used for each spar in the determination of shear loads and material volume. Cap materials are effective bending materials and therefore are assumed to vary with the cover $\bar{t}$ requirements.

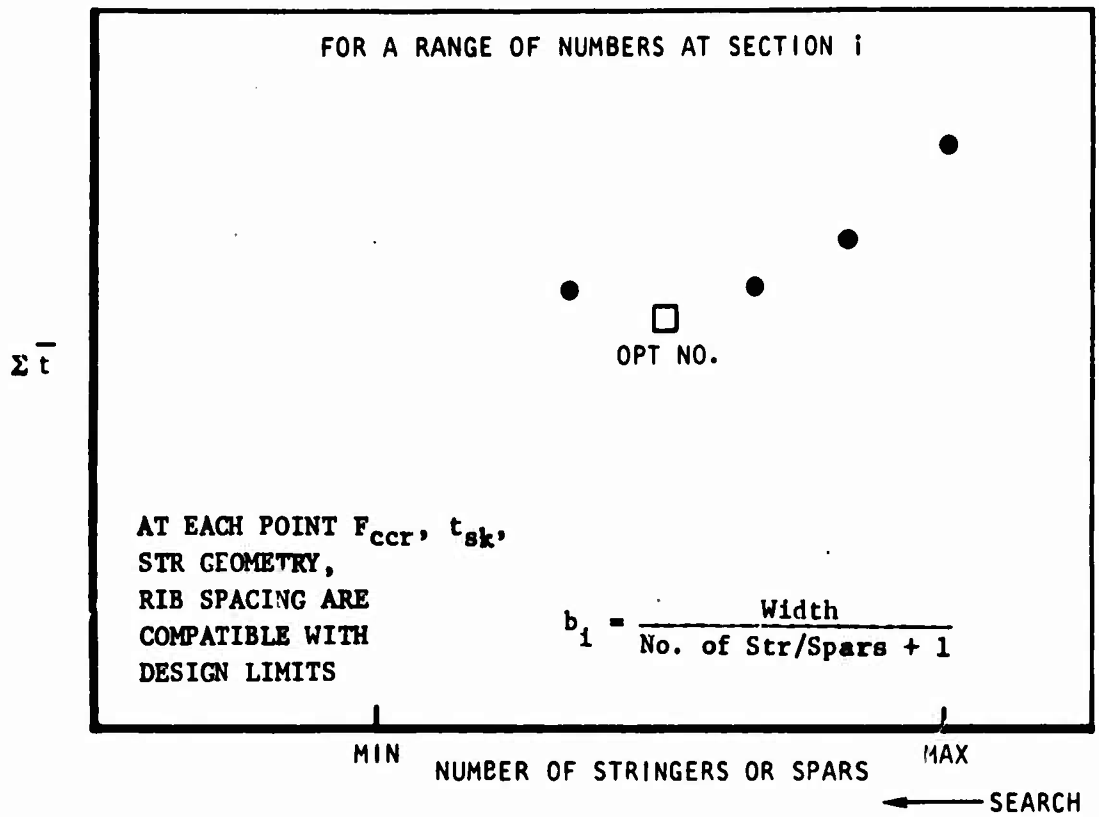


Figure 34. First search level, multirib or multispar construction.

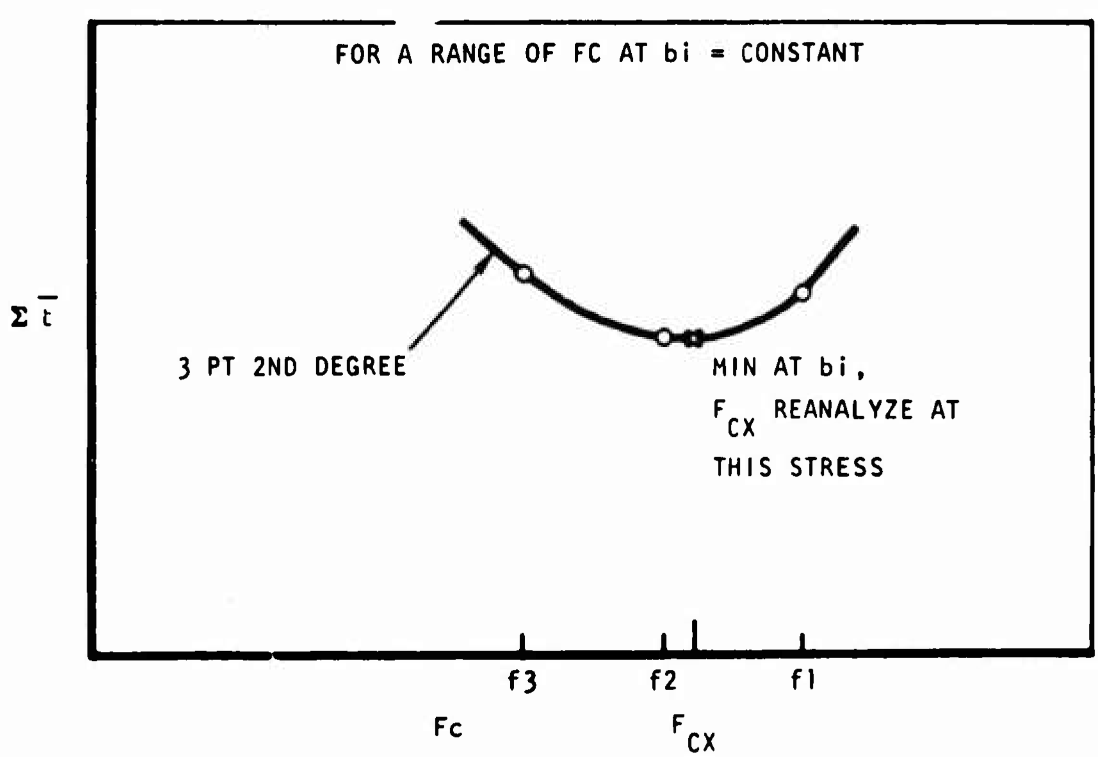


Figure 35. Second search level, multirib.

For each system of cover construction, the bending loads must be resolved into axial loads so that cover and support structure can be synthesized. The synthesis procedure assumes an idealized rectangular box of the same width and cross-sectional area as the section being analyzed, the depth of the section being expressed as the cross-section area divided by the width. This idealization locates the covers relative to each other and provides the basis for resolving the bending loads into axial load components. The moments are resolved into load intensities by an effective couple arm and an effective width: $N_x = M/(D_{eff} \times W_{eff})$. D_{eff} is the distance between the upper and lower cover material centroids, and W_{eff} is the width expression, which includes (1) for the compression loads, the front and rear spar cap and box cover overhand material and, if required, the intermediate cap and/or honeycomb insert material; and (2) for the tension cover loads, the compression cover effective width less the hole-out widths due to attachments for spars or riveted stringers. The effect of Mc/I stresses at the crowns of the box section is accounted for by limiting the strength stress levels at the idealized centroids by assuming that the maximum allowable stress will not be greater than the product of the ratio of d_{ave}/d_{max} times the compression yield stress or the tension ultimate stress of the material.

The synthesis analysis produces initial spanwise sizing distributions for the torque-box components from which spanwise torsional and bending stiffness distributions are derived. These stiffness parameters, plus the weight distributions and structural sizing data, are used in preliminary flutter and loads analysis.

Torsional stiffness requirements at each structural station are expressed in terms of modulus rigidity G times the required section stiffness parameter J. In the section synthesis, the minimum J required at the section will be one limiting constraint on the section web and skin gages. The program determines section stiffness for strengh design from the equation:

$$J = \frac{4A^2}{\Sigma ds/t} \tag{24}$$

Where

A = Enclosed section area within centroids of the four webs

ds = Length of each web

t = Gage of each web

Inadequate strength J at any section is increased to the required J for the flutter stiffness condition by a four-step logical procedure of increasing the smallest gage first. This step procedure will sense the best combination of cover skin and/or spar web gage increments to produce the required section J. The individual web and skin increments are stored for the weight evaluation routines to enable these routines to assess the weight increments required for flutter stiffness. The strength J to required J comparison is performed after the strength sizing requirements have been optimized. Thus, the adjusted skin and spar web gages are used as lower limits for these elements during a final pass through the analysis to reoptimize for combined effects of strength and flutter.

Cover Synthesis

As discussed previously, the torque-box synthesis is designed around the analytical optimization of the compression cover for determination of the best arrangements of skin, stiffening, and support structures. In both multirib and multispar optimization, total $\bar{t}$ (defined as the sum of cover $\bar{t}$, support structure $\bar{t}$, and miscellaneous attachment $\bar{t}$) is minimized with respect to the search level parameters. Synthesis logic and controls are programmed so that only the synthesized sizings that satisfy strength and stability criteria and satisfy boundary conditions such as minimum and maximum stringer or spar spacings, maximum or minimum rib spacings, minimum gages, etc, are selected and returned to the next higher level search as valid points. In most cases, changes in $\bar{t}$ cover results in changes in both skin gages and support structure and attachment $\bar{t}$.

The programmed procedure is a general numerical search synthesis/analysis that is applicable to both multirib and multispar designs. The basic logic is programmed for multirib analysis; with special controls, additional logic and data manipulation, the general search has been adapted for analysis of multispar designs. Numerical optimum search techniques, logic and data manipulation are used to minimize computer execution time. Constant terms or data which appear in repetitive loops are precalculated and stored for general access by all control and computational routines. In the three search/optimization levels, predetermined limits are developed from design control data and used as specifications to (1) provide initial starting values for the search parameter and (2) limit the extent of search within acceptable limits. Parabolic curve and straight-line properties are used to aid in (1) determination of the optimum point, (2) to shorten search computations for solutions that have implicit relations, and (3) to direct the search from parameter values where no solution exist to the value at which a solution exists.

The first aforementioned technique is applicable to the search shown in Figure 35, where the optimum stress is determined for minimum $\bar{t}$ from the derivative of the parabolic curve fitted through the three computed $\bar{t}$ points.

The second technique applies to the search for determining the stress level at which available b/t equals required b/t for specified conditions of stringer or spar spacing, b, load level N_x, and the desired ratio of skin gage to total $\bar{t}$. Since (b/t) required is a function of stress level, $\bar{t}$ is a function of N_x and stress level, and (b/t) available a function of $\bar{t}$, a direct solution cannot be determined over the plastic range of the material. Figure 36 shows the curve fit operation for the first approximation solution for this condition. A special parabolic curve fit/curve evaluation subroutine provides the approximate stress value, F_{co}, that satisfies the conditions (at R = 1.0). A second interpolation is made to improve the accuracy of the solution and insure against improper curve fit resulting from points straddling reflexes in the variation curve.

The third type is used in search levels two and three, when conditions occur such that the region of search on stress levels results in $\bar{t}$ insufficient for (1) required skin material, (2) required stringer area to satisfy geometry and buckling, (3) required stringer area to satisfy column stability, or (4) all three or combinations of the three.

The equivalent $\bar{t}$ representation of supporting structure and attachment $\bar{t}$ in the total $\bar{t}$ equation requires an adjustment coefficient to account for the inequality that exists between the number of spacings and the number of members. The adjustment constant, $K_{\bar{t}s}$, is found from

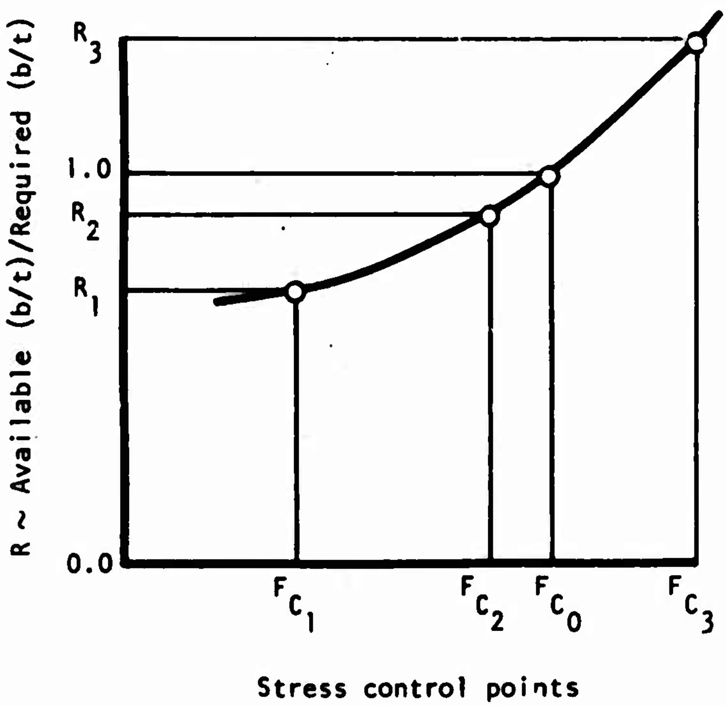
$$K_{\bar{t}s} = \frac{NOS}{NOS + 1} \qquad (25)$$

Where

NOS = Number of support members

This correction factor is also applicable to stringer $\bar{t}$ representation and is necessary for the programmed analysis, since the assumption is made that the total material requirement across the structural width for support members or stringers is equal to the width times $\bar{t}$. Without this factor, inaccuracies occur when the total number of members approach one.

In the first search level, the optimization parameter is NOS, the number of stringer/spar spacings across the structural chord. The range of search is dictated by (1) the specified minimum number of members (NOS_{min}) in the box and (2) the range of spacings to be considered, b_{min} to b_{max}. The control routine evaluates the range in NOS at each local chord where



$$(b/t)\ \text{Required} = \left[\frac{K\pi^2 E_R}{12(1-\mu^2)F_C}\right]^{1/2}$$

$$(b/t)\ \text{Available} = \frac{b}{tsk}$$

$$tsk = K_{sk}\frac{Nx}{Fc}$$

Figure 36. Interpolation scheme for stress level.

$$NOS_{b_{min}} = \frac{W}{b_{min}} - 1 \tag{26}$$

$$NOS_{b_{max}} = \frac{W}{b_{max}} - 1 \tag{27}$$

The maximum NOS is specified by b_{min}, while the minimum is specified by b_{max}. A logical check is made against the specified NOS_{min} to insure the NOS derived from Equations 26 and 27 are acceptable. This results in search boundaries for the number of stringers or spars. If the specified NOS_{min} is larger than the values determined by Equations 26 and 27, evaluation is made only at NOS_{min}. Computed NOS is always rounded to integer sets unless the input data set control specifies a primary search for stringer spacings.

The current search value of NOS is specified to the next level control. In this routine, the highest stress level that satisfies load and cover configuration specifications is determined for the current value of NOS. Preliminary computations for starting values of stress levels are estimated for limiting conditions. The lowest stress value is then used to start the search, which is schematically shown in Figure 35. The limiting stress values examined are:

1. Maximum allowable stress level, F_{CMAX}

2. Stress level at minimum gage condition, for stringers:

$$f = \frac{N_x}{\bar{t}_{min}} \tag{28}$$

$$\bar{t}_{min} = t_{skin\ min} + \frac{A_{str\ min}}{b_{str}} \tag{28a}$$

$$A_{str\ min} = t_{str}\ \text{[developed length of minimum size stronger]} \tag{28b}$$

3. Stress level at condition where available (b/t) is equal to required (b/t) for skin buckling determined from Equation 22. This

stress level is determined by numerical interpolation, as discussed previously.

4. Stress level determined for available (b/t) where $t = t_{skin\ min}$

Stress level search values are specified to the third-level search control where cover configurations are synthesized. The stringer synthesis procedure distributes the available material determined from $\bar{t} = N_x/f_c$. This $\bar{t}$ is distributed into skin and stringer material so that all elements satisfy local stability requirements and all specified geometric constraints of minimum gages and minimum and maximum stringer geometries. Available stringer column is checked if the preceding conditions are satisfied; the configuration is accepted if the stringer column length is greater than the specified minimum rib spacing, rejected if it is less. Specified stress levels with available cover material that cannot be distributed to satisfy all these conditions are rejected and control returned to the second level, where the rejection condition indicator is examined to control the search for a lower acceptable stress level. Skin material, t_{skin}, is optimized in the third search level for the highest radius of gyration for the stringer column, resulting in logic designed to maximize stringer area and height. Thus, t_{skin} can be optimized against total $\bar{t}$, since stringer radius of gyrations dictates stringer column available at any stress level (Equation 23), resulting in changes in $\bar{t}$ support and attachments.

Skin gages satisfying (1) plate buckling stability (b/t), (2) $\bar{t}$ skin min, and (3) material distribution range $R_{SKIN\ MIN}$ and $R_{SKIN\ MAX}$ are examined to identify the range of acceptable gages to be used in the search. R_{SKIN} is the search control parameter used to control material distribution between skins and stringers and is the ratio of skin thickness to cover $\bar{t}$. The minimum search value gage is the larger of the preceding items 1 and 2, and the gage determined from $R_{SKIN\ MIM} X\ \bar{t}$. The maximum value is the gage specified by $R_{SKIN\ MAX}\ X\ \bar{t}$. If the minimum search value is greater than the maximum (where b/(b/t) is less than $R_{SKIN\ MAX}\ X\ \bar{t}$), the current stress level is rejected and control returned to the second level.

Acceptable skin gages, t_{skin}, then result in values of stringer areas, since:

$$\bar{t}_{str} = \bar{t} - \bar{t}_{skin} \tag{29}$$

$$A_{str} = b \times \bar{t}_{str} \tag{29a}$$

The skin gage is rejected if A_{str} is less than $A_{str\ min}$. Acceptable stringer areas are then distributed into the stringer elements to satisfy local

stability conditions and stringer geometry constraints, based on the type of stringer configuration desired (Figure 32).

Figure 37 shows a riveted stringer configuration and the equations for determining cross-sectional properties from sizing data for evaluation of allowable rib spacing, L_{col}. The stringer gage, t_{str}; height, h; and flange lengths, fu and fL, are determined for the available stringer such that h/t_{str}, fL/t_{str} satisfy the allowable (b/t)'s for these elements. The buckling coefficient is assumed to be 4.0 for the web and 0.426 for the flanges. The stringer gage is dictated by one of the following conditions or combinations:

1. Minimum gage

2. Minimum size assigned to h, fu, fL

3. Web b/t

4. Flange b/t

5. Maximum size assigned to h, fu, fL

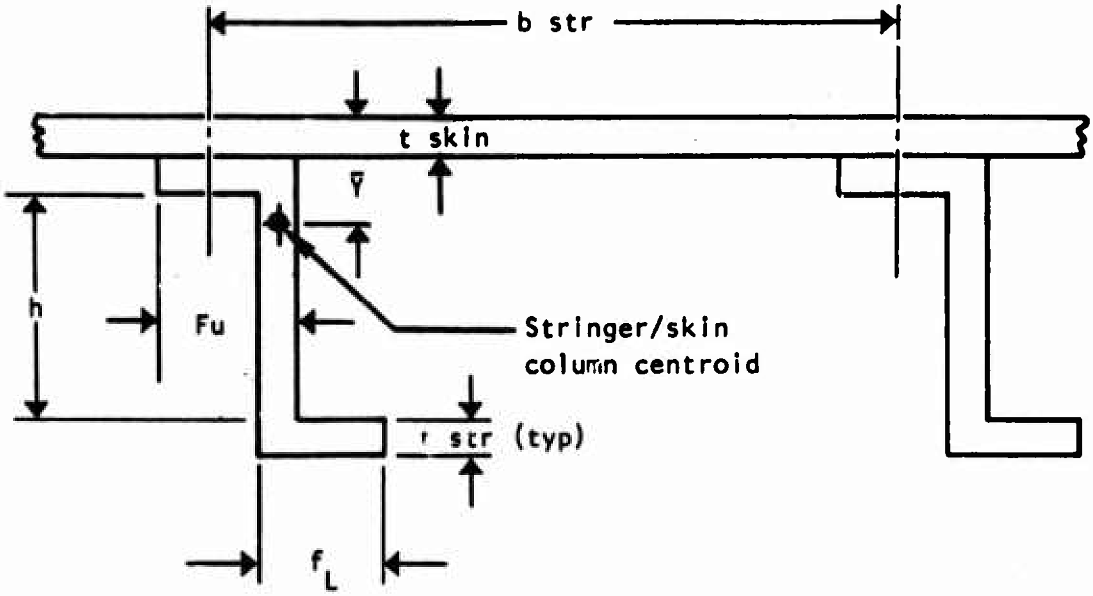
Thus, t_{str}, h, fu and fL are evaluated from one of the following sets of equations by logically determining the controlling parameter for the given set of conditions:

1. For h, fu, fL within minimum and maximum sizes:

$$t_{str} = \left[\frac{A_{str}}{(b/t)_h + 2(b/t)_f}\right]^{1/2} \tag{30}$$

$$h = t_{str}\,(b/t)_h$$

$$fu = fL = t_{str}\,(b/t)_f$$



$$A = A\ SKIN + A\ STR$$

$$A\ SKIN = t\ SKIN \times b$$

$$A\ STR = A_h + A_{fu} + A_{fL} = t\ STR\ (h + fu + fL)$$

$$\bar{Y} = \frac{1}{A}\left[A\ SKIN \times \frac{t\ SKIN}{2} + A_h\left(\frac{h}{2} + t\ STR + t\ SKIN\right) + A_{fu}\left(\frac{t\ STR}{2} + t\ SKIN\right)\right.$$
$$\left. A_{fL}\left(\frac{t\ STR}{2} + h + t\ STR + t\ SKIN\right)\right]$$

$$I_o = \frac{1}{12}\left[b \cdot t\ SKIN^3 + t\ STR \cdot h^3 + t\ STR^3 (fu + fL)\right] + A\ SKIN\left(\bar{Y} - \frac{t\ SKIN}{2}\right)^2$$
$$+ Ah\left(\bar{Y} - \frac{h}{2} - t\ STR - t\ SKIN\right)^2 + A_{fu}\left(\bar{Y} - \frac{t\ STR}{2} - t\ SKIN\right)^2$$
$$+ A_{fL}\left(\bar{Y} - \frac{t\ STR}{2} - h - t\ STR - t\ SKIN\right)^2$$

$$\rho = \left[\frac{I_o}{A}\right]$$

$$L_{COL} = \left[\frac{\pi^2 E_t\ \rho^2}{F_c}\right]^{1/2}$$

Figure 37. Stringer-column geometry.

2. For $fu = fL = f_{max}$, h within minimum and maximum sizes:

$$t_{str} = \frac{-2f_{max} + \left[2f_{max} + 4\ A_{str}\ (b/t)_h\right]^{1/2}}{2(b/t)_h} \tag{31}$$

$$h = t_{str}(b/t)_h$$

3. For $fu = fu_{min}$, h, and fL within minimum and maximum sizes:

$$t_{str} = \frac{-fu_{min} + \left[fu_{min}^{\ 2} + 4\ A_{str}\left\{(b/t)_h + (b/t)_f\right\}\right]^{1/2}}{2\left\{(b/t)_h + (b/t)_f\right\}}$$

$$h = t_{str}\ (b/t)_h \tag{32}$$

$$f_L = t_{str}\ (b/t)_f$$

4. For $h = h_{max}$, $fu = fL$ within minimum and maximum sizes:

$$t_{str} = \frac{-h_{max} + \left[h_{max}^{\ 2} + 4\ A_{str}\left\{2(b/t)_f\right\}\right]^{1/2}}{2\left\{2(b/t)_f\right\}} \tag{33}$$

$$fu = fL = t_{str}\ (b/t)_f$$

5. For $h = h_{max}$, $fu = fu_{min}$, fL within minimum and maximum sizes:

$$t_{str} = \frac{-(fL_{max} + fu_{min}) + \left[\left(h_{max} + fu_{min}\right)^2 + A_{str}(b/t)_f\right]^{1/2}}{2(b/t)_f}$$

$$f_L = t_{str}\ (b/t)_f \tag{34}$$

The h_{min} condition is one of the control points in the synthesis; tstr for this point determined from tstr = $fL_{min}/(b/t)f$, gage checked against stringer minimum gage, then fu calculated. If tstr is less than minimum, the current stringer is rejected and control passed to the tskin search routine with the proper rejection status indicator. Acceptable tstr condition results in checks for available to required minimum developed length. If this condition is satisfied, the solution is, at this point or in the tstr region, dictated by control parameters found in items 1 through 5.

The area distributions for integral Z-stringers are based on the equations found in 1, 2, and 4, except that fu is set to zero. Angle stringers are treated with same equations, except that the buckling coefficient for $(b/t)_h$ is set to 0.426.

Integral I-stringer equations following are modified forms of 1 and 4, with $(b/t)_h$ computed with the buckling coefficient set to 0.426.

6. For h within minimum and maximum sizes:

$$t_{str} = \left[\frac{A_{str}}{(b/t)_h}\right]^{1/2} \tag{35}$$

$$h = t_{str}\,(b/t)_h$$

7. For $h = h_{max}$:

$$t_{str} = A_{str}/h_{max} \tag{36}$$

8. For $h = h_{min}$, $tstr \geq t$ min gage:

$$t_{str} = A_{str}/h_{min} \tag{37}$$

Intermediate Support Structure

Intermediate ribs and spars are treated as corrugated web/cap structure located through (1) input data set specifications or (2) at spacings to provide support for general stability of covers under compression loadings.

In general, the spacings are not specified; therefore, in stringer designs, the available column length of the stringer column is determined from the stability equation for long columns, Equation 23.

Support structure $\bar{t}$ is expressed as the sum of the cover-material equivalet volume of web, cap, and attachments divided by the planform area of distribution. The distribution area is the structural width times the rib spacings for multirib designs and spar spacing for multispar designs, if the volume is expressed in unit span values. Thus:

$$\bar{t}_{rib} = \frac{1}{C_{sc} \cdot L_{rib}} \left[\frac{W_{web} + W_{caps} + W_{attachments}}{\rho_{cover}} \right] \tag{38}$$

Where

C_{sc} = Structural width

ρ_{cover} = Density of the cover material

The rib web is assumed to act as a column which provides the strength and stiffness at the stringer column ends necessary to prevent cover general instability failures and to react the crushing loads due to torque-box bending stresses. Support stiffness requirements are determined from:

$$L = \frac{2\pi M}{E_{rib} \, W \, \bar{t}_r} \tag{39}$$

Where

L = Rib spacing

M = Bending moment

E_{rib} = Elastic modules of the web material

W = Structural width

$\bar{t}_r$ = Equivalent rib gage

By assuming that M/W can be related to cover loading by the equation

$$M/W = Nx \times D_{eff} \tag{40}$$

Equation (39) reduces to:

$$\bar{t}_r = \frac{2\pi}{E_{rib}} N_x \frac{D_{eff}}{L} \tag{41}$$

Rib loads due to crushing loads from cover panels are determined from:

$$\sigma_{rib} = \frac{2L\, \sigma_c^2\, \bar{t}_c}{E_T\, D_{eff}\, \bar{t}_r} \tag{42}$$

Where

σ_c = Compression stress in the cover

$\bar{t}_c$ = Compression cover $\bar{t}$

E_T = Tangent modules of the cover

$\bar{t}_r$ = Effective rib web material

Since σ_c/E_T is equal to the strain, ε, at the compression stress level, and $\bar{t}_c\, \sigma_c = N_x$, Equation 43 can be solved for the effective rib $\bar{t}_r$ required or:

$$\bar{t}_r = \frac{2N_x\, \varepsilon L}{\sigma_{rib}\, D_{eff}} \tag{43}$$

Since the rib web acts as compression columns, the rib material must be distributed to prevent local and general instability failures. For 60-degree circular corrugated webs with radius R, the local stability allowable is expressed by:

$$\sigma_{scr} = 0.4E_T\, (t/R) \tag{44}$$

Where, E_r, the reduced modulus is determined as:

$$E_r = \left(E_T E\right)^{1/2} \tag{44a}$$

General instability allowable is found from the general column equation

$$\sigma_{scr} = \pi^2 E_r \left(\frac{\rho}{\ell}\right) \tag{45}$$

or

$$\sigma_{scr} = 1.425\ E_T \frac{R^2}{D_{eff}} \tag{45a}$$

The equivalent $\bar{t}$ for corrugated ribs is determined from the product of the corrugation factor times the web gage where the corrugation factor CF is:

$$CF = \frac{2}{3}\pi R/2R \text{ Sin } 60° = 1.2092 \tag{46}$$

Thus, the applied compression stress from Equation 42 and the required $\bar{t}_r$ for stiffness can be related to the corrugated web gage. The rib synthesis routine determines the required web gage and/or corrugation radius to provide the stiffness required and insure that the applied stress is within the allowables specified by Equations 44 and 45.

The equivalent cross-sectional area of the rib is estimated from the equation:

$$A_{web} = \left[D_{eff} - 2(tsk + tw) + 2L_{CAPS}\right] tw \cdot CF \tag{47}$$

Attachment and miscellaneous material required is expressed as:

$$A_{misc} = \left[K \frac{2}{b_{str}} (1.5 + fu)(0.75\ h_{str})\ tw\right] \tag{48}$$

Where

K = Constant = 1.15

f_u = Riveting stringer flange, if riveted Z or angle

h_{str} = Stringer height

Thus, $\bar{t}$ rib for optimization and weight can be computed as:

$$\bar{t}_{rib} = \frac{1}{L_{rib}} [A_{web} + A_{misc}] \qquad (49)$$

Front and Rear Spars

Front and rear spars are treated as shear-carrying members consisting of caps and web structures plus attachments. The webs are assumed to be flat plates with attached angle stiffeners resisting the vertical shears at the front and rear spars:

$$f_s = \frac{q}{t_w} \qquad (50)$$

Where

f_s = Shear stress in the web, pounds per square inch

q = Shear load, pounds per inch

t_w = Web gage, inches

Allowable shear stresses are determined for the web based on the plate aspect ratio between stiffeners and the effect of bending stresses. For pure shear, the equation for critical shearing stress is:

$$f_{scr} = \frac{K_1 \pi^2 E_r}{12(1-u^2)} (t/b)^2 \qquad (51)$$

Where

K_1 = Shear buckling constant for panel aspect ratio b/a (b = short dimension, a = long dimension), for plates with all sides simply supported

A straight-line table interpolation scheme is used to determine K_1 for derived b/a values.

Combined shear and bending allowables are determined from the equation:

$$f_{scr} = \frac{K_s \pi^2 E_r}{12(1-u^2)} (t/d)^2 \qquad (52)$$

Where

$$K_s = 5.35 \left[\frac{1}{1 + 0.05\left(\frac{\sigma_c}{f_s}\right)^2} \right]^{1/2} \qquad (52a)$$

σ_c = Bending compression stress

f_s = Applied shear stress = q/tw

The peak compression stress, σ_c, is based on the compression cover stress at the cover centroid and the mold line depth at the spars less an incremental depth for cap allowance. If the web depth is d_w, then:

$$\sigma_c = \frac{d_w}{D_{eff}} \times \sigma_{cov} \qquad (53)$$

An iterative search routine is programmed to determine the web gage which results in shear stresses that satisfy Equations 51 and 52. Stiffeners are assumed to be spaced 6 inches on center, but can be changed in the input data set. Stiffener gage is assumed to be equal to the web gage; the flange width is assumed to be equal to 0.75 x L_{cap} (L_{cap} = spar cap overhang forward or aft of the front and rear spar planes).

Spar caps are based on assumed widths of cover $\bar{t}$ at the station analyzed, provided that the indicated cap gage defined by the cap area divided by a predetermined cap developed length is not less than an assumed cap minimum gage. This cap minimum gage is generally larger than the web or cover skin minimum gage, due to attachment requirements or allowance for groove sealing provisions (0.156 for aluminum, and 0.100 for titanium caps). Miscellaneous attachment requirements are estimated as a fraction of the total requirements at the station (0.0250).

Bending and Torsional Stiffness

The detail structural sizings resulting from synthesis of the torque-box structure provides data from which initial estimates can be made of bending and torsional stiffness distributions along the structural span. These structural characteristics are based on the idealized rectangular box section. The box system is assumed to be single celled with neutral axis at the centroid of the idealized box.

Bending stiffness, EI, is determined from chordwise summation of cover Io's and transfer terms times the elastic modulus of the compression cover material. Correction factors for E can be specified in the input data set if the lower cover, front spar, and rear spar elastic modulus are different from the upper cover. Front and rear spar cap transfer terms are based on distances derived from spar mold line depths and estimated spar cap entroids.

Torsional stiffness, GJ, is determined from the product of the section stiffness parameter (J) of the assumed single-cell, four-web box and the compression cover shear modulus, G. J is determined by Equation 24. The ds/t term of this equation is computed for each web, thus:

$$\Sigma\, ds/t = \frac{W}{t_{\text{skin upper}}} + \frac{W}{t_{\text{skin lower}}} + \frac{d_{fs}}{t_{fs}} + \frac{d_{rs}}{t_{rs}} \tag{54}$$

At structural stations where section J resulting from strength-sized webs is less than the J required for flutter, the evaluation routine first orders web and length data into a data set from which the element with smallest gage is first selected for web gage change to increase the section J. A step-wise increase is made until (1) the section stiffness parameter is equal to the required or (2) the three smaller webs have been increased to the thickness of the largest web. If condition 2 does not result in required J, all webs are incremented equally to produce the desired value of J.

The synthesis control routine identifies all webs that are changed in size and provides for resizing of these elements, with the condition that the flutter required web gages be treated as minimum web gages, in lieu of the fabrication minimum gages. The resized section data are than processed for final evaluation of section bending and torsional stiffness characteristics.

Strength-sized design data and flutter-sized data are ordered for the torque-box weight analysis routines so that estimates of weight and distributions can be made for both strength as well as combined strength and torsional stiffness requirements.

Advanced Composite Torque-Box Analysis

The programmed advanced composite analysis is designed to determine structural requirements of torque boxes constructed with all cover and supporting structures fabricated with laminated layers of filamentary fibers. The prediction procedure determines the necessary number and orientation of fiber layers to provide the strength, stability, and stiffness characteristics required for each element of the box. Assumptions are made to adapt detail analysis procedures to the quick-response, preliminary nature of the synthesis procedures. Equations used to evaluate the behavior of laminated webs under load are based on existing detail filamentary analysis equations. Where possible, similarity to the metallic structure analysis is maintained; structural idealization assumptions and scope of the synthesis/weight analysis procedures are similar.

Torque-box construction types that can be analyzed include:

1. Multispar plate cover designs

2. Multirib stringer-stiffened cover designs

3. Full-depth honeycomb sandwich designs

Spar and rib support structures are idealized as sheet web plus cap systems; the webs for these structures can be designed as either corrugate webs or honeycomb panels. The cover and support structures are assumed to be mechanically fastened at cover-to-spar/rib joints to provide an integrated torque-box structure. Face sheets for full-depth honeycomb sandwich boxes are assumed to be bonded to the supporting core material.

General Behavior of Composite Laminates

An advanced composite material is made up of high-strength/stiffness fibers imbedded within an essentially homogeneous matrix. Typical materials

are (fiber/matrix) boron/epoxy, graphite/epoxy (high-modulus, intermediate-strength, high-strength), and boron/aluminum. In general, these materials have high-strength/stiffness properties in the longitudinal (parallel to the fiber) direction, and a low-stiffness/strength in the transverse direction. Layers (lamina) of these materials can be laid up to produce a laminate; stiffness and strength properties of the laminate are tailored by varying the orientation and number of layers.

The programmed analysis assumes lamina of three discrete orientations to make up laminates (Figure 38). These are 0, 90, and ±45 degrees. The ±45-degree lamina is not really one lamina, but two laminas oriented at 90 degrees to each other.

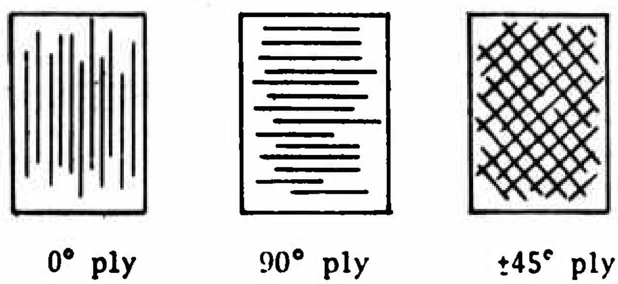


Figure 38. Composite-ply orientations

Plies oriented at 0 degree (longitudinal) are strongest in the axial direction, while the ±45-degree plies are best at resisting shear. 90-degree plies are added to keep the laminate balanced. Although the order in which these laminae are laid up has a bearing on the properties of the laminate, a particular layup sequence is not implied in the sizing results; i.e., computations are based on an equivalent number of plies in a homogeneous (as opposed to layered) laminate.

Certain general assumptions about the failure of a laminate are made to simplify the analysis. These assumptions are:

1. That the laminate must contain enough plies with their fibers oriented parallel to the axis of the principal axial load (the 0-degree direction for the member) to carry the axial load without failure.

2. That the laminate must contain enough ply-pairs oriented at ±45 degrees to the 0-degree direction to carry the applied shear load.

3. An additional c-percent more plies oriented at 90 degrees are added to carry any in-place loads transverse to the 0-degree direction (a default value of 0.10 is assumed for c).

This predetermines the laminate configuration to be

$$\left[0°_{\ell}/\pm45°_{m}/90°_{n}\right]_{s}$$

where ℓ = number of 0-degree plies, m = number of ±45-degree sets, and n = number of 90-degree plies in half of the laminate, Figure 39. This configuration was chosen because in-plane axial loads are most efficiently carried with plies oriented along the axis of these loads, while shear loads are most efficiently carried by pairs of plies oriented at ±45 degrees to the 0-degree direction.

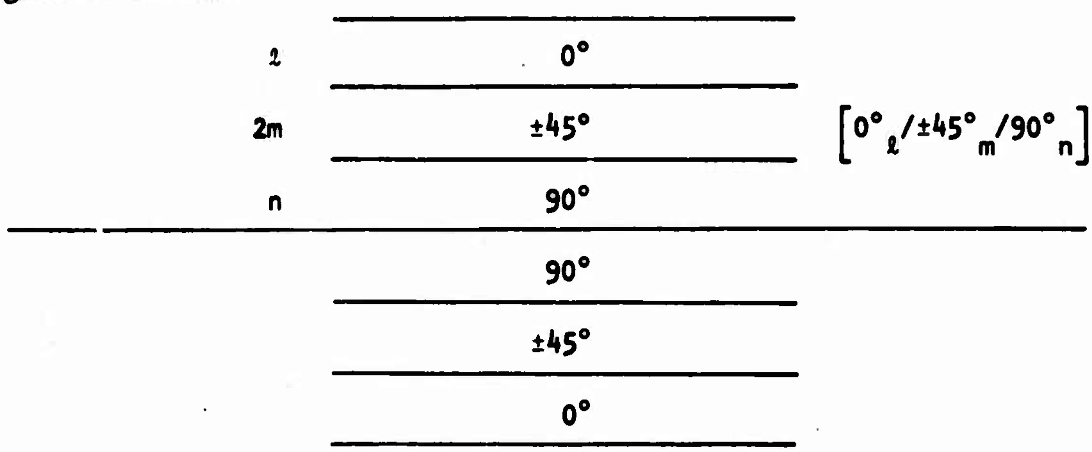


Figure 39. Laminate configuration.

All laminates are assumed to be balanced. This means that there are as many plies at $+\theta$ degrees from the 0-degree direction as there are at $-\theta$ degrees from the 0-degree direction. All laminates are also assumed to be symmetric; that is, they are symmetric about the middle surface of the laminate.

If a laminate was specified as having L = 5, M = 7, N = 2, then it would have 10 0-degree plies, 14 ±45-degree-sets of plies, and four 90-degree plies. Although the order in which these plies are laid up makes a difference in the final properties, the derived equations assume that each type of ply is spread homogeneously throughout the thickness of the laminate.

Governing Relationships

The governing equations of lamination theory are presented in the following paragraphs. These are used to derive material constant equations necessary for the analysis. Further information regarding these equations is available in "Advanced Composite Design Guide," Volume 2.

An orthotropic composite material is characterized by the elastic constants E_L, E_t, G_{LT}, and ν_{LT}, and the allowable stresses F_0^{tu}, F_0^{cu}, and $F^{su}_{\pm 45}$. Further, the physical constants ρ and t_L are necessary. The stress-strain relationship for a composite laminate is expressed by:

$$\begin{bmatrix} N_x \\ N_y \\ N_{xy} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_{xy} \end{bmatrix} \tag{55}$$

The A-matrix is the stiffness of the laminate and is used in many places in the program. The assumption that the laminate is balanced implies that there is no coupling between ε_{xy} and N_x or N_y (also between ε_x and ε_y and N_{xy}). This assumption is enforced by setting A_{13}, A_{23}, A_{31}, and A_{32} equal to zero. Also, due to symmetry, A_{12} must equal A_{21}. Thus, the A-matrix has only four independent components:

$$A = \begin{bmatrix} A_{11} & A_{12} & 0 \\ A_{12} & A_{22} & 0 \\ 0 & 0 & A_{33} \end{bmatrix} \tag{56}$$

The A-matrix can be calculated from the elastic constants, using the following relations:

$$A_{iJ} = \sum_{K=1,NL} t_K \, Q_{iJ}^{(K)} \tag{57}$$

Where

$i = 1, 2, 3$

$J = 1, 2, 3$

where K refers to the Kth layer and NL is the number of layers, the Q-matrix is calculated for each layer, using the transformation equations:

$$Q_{11}^{\theta} = m^4\bar{Q}_{11} + 2m^2n^2(\bar{Q}_{12} + 2\bar{Q}_{66}) + n^4\bar{Q}_{22} \tag{58}$$

$$Q_{12}^{\theta} = m^2n^2(\bar{Q}_{11} + \bar{Q}_{22} - 4\bar{Q}_{66}) + (m^4 + n^4)\bar{Q}_{12} \tag{59}$$

$$Q_{22} = n^4\bar{Q}_{11} + 2m^2n^2(\bar{Q}_{12} + 2\bar{Q}_{66}) + m^4\bar{Q}_{22} \tag{60}$$

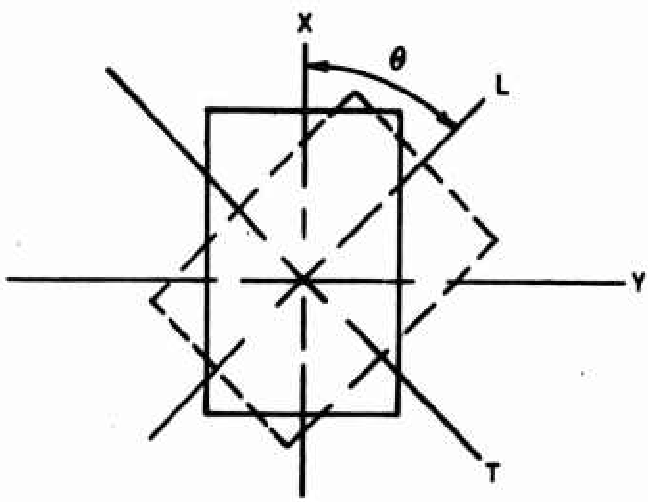
$$Q_{66} = m^2n^2(\bar{Q}_{11} + \bar{Q}_{22} - 2\bar{Q}_{12} - 2\bar{Q}_{66}) + (m^4 + n^4)\bar{Q}_{66} \tag{61}$$

where

$m = \cos$

$n = \sin$

The Q-matrix represents the stress-strain relationship of one lamina written in the laminate orientation system (x, y) shown in the following sketch. θ is the angle between the laminate coordinate system and the lamina coordinate system. The $\bar{Q}$-matrix is the stress-strain relationship written in the lamina coordinate system (L, T).



The $\bar{Q}$-matrix can be calculated directly from the elastic constants using:

$$\bar{Q}_{11} = \frac{E_L}{(1 - \nu_{LT}\nu_{TL})} \tag{62}$$

$$\bar{Q}_{22} = \frac{E_T}{(1 - \nu_{LT}\nu_{TL})} \tag{63}$$

$$\bar{Q}_{12} = \nu_{LT}\bar{Q}_{22} \tag{64}$$

$$\bar{Q}_{66} = G_{LT} \tag{65}$$

Note that:

$$\bar{Q}_{13} = \bar{Q}_{23} = \bar{Q}_{31} = \bar{Q}_{32} = 0$$

and

$$\bar{Q}_{21} = \bar{Q}_{12}$$

For the specific case of a laminate with the configuration

$$\left[0°_{\ell}/\pm45°_{m}/90°_{n}\right]_{s} ,$$

the calculation of the A-matrix can be simplified by noting that only six elements of the Q-matrices are used to calculate the stiffness of a laminate with any ℓ, m, and n. Using Equations 58 through 65 for a 0-degree ply:

$$Q^{0}_{11} = \frac{E_L}{(1 - \nu_{LT}\nu_{TL})}$$

$$Q_{22}^{0} = \frac{E_T}{(1 - \nu_{LT}\nu_{TL})}$$

$$Q_{12}^{0} = \nu_{LT}Q_{22}^{0} = \nu_{TL}\ Q_{11}^{0}$$

$$Q_{66}^{0} = G_{LT}, \text{ all remaining } Q = 0 \qquad (66)$$

For a 90-degree ply:

$$Q_{11}^{90} = Q_{22}^{0}$$

$$Q_{22}^{90} = Q_{11}^{0}$$

$$Q_{12}^{90} = Q_{12}^{0}$$

$$Q_{66}^{90} = G_{LT} \qquad (67)$$

All remaining Q = 0.

For a ±45-degree-ply set:

$$Q_{11}^{45} = Q_{22}^{45} = 0.25\left[Q_{11} + Q_{22} + 2(Q_{12} + 2G_{LT})\right]$$

$$Q_{12}^{45} = 0.25\ (Q_{11} + Q_{22} - 4G_{LT} + 2Q_{12})$$

$$Q_{66}^{45} = 0.25\ (Q_{11} + Q_{22} - 2Q_{12}) \qquad (68)$$

A new notation can be introduced that corresponds with the computations in the programmed analysis:

$$Q_1 = Q_{11}^{0}$$

$$Q_2 = Q_{22}^{0}$$

$$Q_3 = Q_{12}^{0}$$

$$Q_4 = Q_{11}^{45}$$

$$Q_5 = Q_{12}^{45} \tag{69}$$

Q_{66}^{45} is calculated as needed.

For a composite laminate subject to N_x and N_{xy} loads, the following design equations apply:

$$\ell = \frac{N_x}{2t_L F_0^{tu}} \quad ; \quad N_x < 0, \text{ tension loads} \tag{70}$$

$$\ell = \frac{N_x}{2t_L F_0^{cu}} \quad ; \quad N_x > 0, \text{ compression loads} \tag{71}$$

$$m = \frac{N_{xy}}{4t_L F_{45}^{su}} \tag{72}$$

$$n = c(\ell + 2m) \tag{73}$$

Where c is an arbitrary fraction. The following constants are useful for repeated calculations:

$$X_1 = 2t_L F_0^{cu}$$

$$X_2 = 2t_L F_0^{tu}$$

$$X_3 = 4t_L F_{45}^{su} \tag{74}$$

At times, it is necessary to calculate the gross elastic properties of a laminate, E_x and G_{xy}. The equations used are as follows:

$$E = \frac{2t_L}{t}(\ell Q_1 + 2mQ_4 + nQ_2) \tag{75}$$

$$G = \frac{2t_L}{t}\left[\frac{m}{2}(Q_1 + Q_2 - 2Q_3) + (\ell + n)G_{LT}\right] \tag{76}$$

Where

$$t = (\ell + 2m + n)2t_L \tag{77}$$

t_L = thickness of lamina, inches

Temperature Dependence of Properties

All engineering materials are subject to changes in properties at elevated temperatures. To account for these changes, all necessary material constants are computed as a function of the design temperature for each set of design loads. The properties affected by temperature are E_L, E_T, G_{LT}, ν_{LT}, F_0^{tu}, F_0^{cu}, and F_{45}^{su}. The material constants that must be calculated as a function of temperature are Q_1, Q_2, Q_3, Q_4, Q_5, G_{LT}, X_1, X_2, and X_3. (Refer to Equations 69 through 74.) In addition, the extentional and shear modulus of the material for the honeycomb core used on some designs are also subject to temperature variation.

The method chosen to compute these at-temperature properties is straight-line interpolation of specified properties at predetermined control points. Since most advanced composites with epoxy matrix materials are

unusable at temperatures above 350° F, a temperature range of 0° to 400° F is used. The program accepts as input to a temperature compensation table, factors of 1 to 100, or greater, that represent the percent of the room-temperature property available at 0, 100, 200, 300, and 400° F. Properties at a specific temperature, P_T, are determined from the room-temperature property P_{RT}, using the following formula:

$$P_T = P_{RT} \cdot \left(\frac{T-T_N}{100}\right) \cdot \left[\frac{T_c(N) - T_c(N+1)}{100}\right] \tag{78}$$

Where:

T = Temperature

T_N = Temperature compensation table temperature immediately below T

$T_c(N)$ = Temperature compensation table value just below T

$T_c(N+1)$ = Temperature compensation table value immediately above T

Temperature-dependent properties are computed and stored for each of the up to 20 load cases analyzed, each set computed at the design temperature for the load condition. Additionally, up to four other temperature sets are created to be used for evaluation of torque-box stiffness distributions at the specified reference temperatures. These computations are made by subroutine TEMPC.

Stability

In general, four types of structural members need to be checked for stability under axial and shear in-plane loads. These structures, shown in Figure 40, are:

1. Advanced composite plate skins

2. Advanced composite sine wave spar or rib webs

3. Honeycomb panel covers with advanced composite face sheets

4. Honeycomb panel webs with advanced composite face sheets

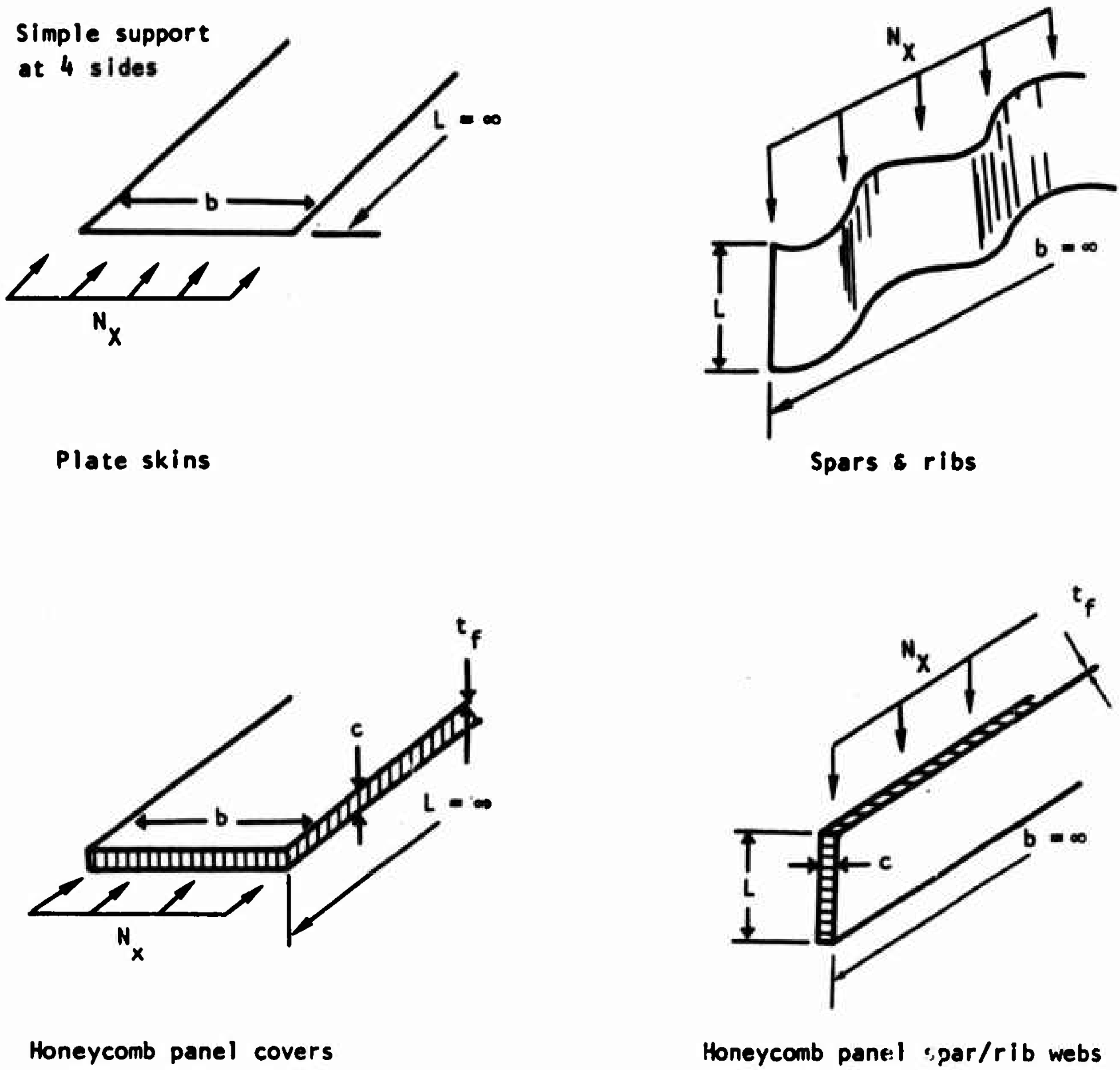


Figure 40. Advanced composite structures checked for stability.

It can been seen that skins will buckle in a plate mode, while spars will buckle in a column mode. The equations for each of these modes involve some of the following plate bending rigidities. For advanced composites skins:

$$D_{11} = A_{11} \frac{t^2}{12} \tag{79}$$

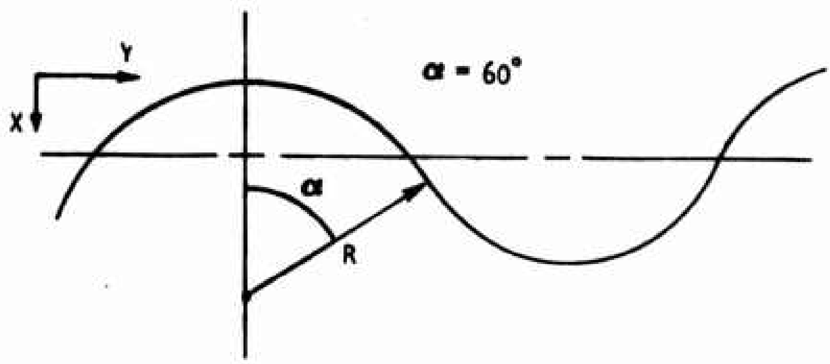
$$D_{22} = A_{22} \frac{t^2}{12} \tag{80}$$

$$D_{12} = A_{12} \frac{t^2}{12} \tag{81}$$

$$D_{66} = G_{LT}(\ell + n) + (Q_1 + Q_2 - 2Q_3) \frac{m}{2} \tag{82}$$

$$D_{12}^{*} = D_{12} + 2D_{66} \tag{83}$$

For advanced composite circular corrugated webs, 120-degree corrugation, as shown:



$$\tilde{D}_{11} = \frac{(EI)_x}{1 - \nu_{xy}\nu_{yx}} \tag{84}$$

$$I = \frac{R^2 t}{2} \frac{3\alpha}{\sin \alpha} - 2\alpha \sin \alpha - 3 \cos \alpha$$

$$I = 0.157\ R^2 t \tag{85}$$

$$\frac{E_x}{(1 - \nu_{xy}\nu_{yx})} = \frac{A_{11}}{t} \tag{86}$$

$$\tilde{D}_{11} = 0.157\ R^2 A_{11} \tag{87}$$

$$\tilde{D}_{22} = D_{22} \cdot \frac{1}{1.21} \tag{88}$$

$$\tilde{D}_{12} = D_{12} \cdot \frac{1}{1.21} \tag{89}$$

For honeycomb panels with advanced composite face sheets:

$$\begin{aligned} D_{11} &= A_{11} \frac{\left(c + t_f\right)^2}{2} \\ D_{22} &= A_{22} \frac{(c + t_f)^2}{2} \\ D_{12} &= A_{12} \frac{(c + t_f)^2}{2} \\ D_{66} &= A_{66} \frac{(c + t_f)^2}{2} \end{aligned} \tag{90}$$

The shear buckling loads for both plates and wide columns are predicted by the following equations. For $\theta \leq 1$:

$$N_{xycr} = \frac{4K_v}{b^2} (D_{22}D^*_{12})^{1/2} (0.938\theta^2 + 0.582\theta + 11.7) \tag{91}$$

For $\theta \geq 1$:

$$N_{xycr} = \frac{4K_v}{b^2} (D_{11}D_{22}{}^3) (8.125 + \frac{5.05}{\theta}) \tag{92}$$

Where

$$\theta = \frac{(D_{11}D_{22})^{1/2}}{D_{12}^{*}}$$

$K_v = 1$ for advanced composite plates

and

$$K_v = \frac{1 - B_3Z}{1 - B_3Z - 4B_1Z} \quad \text{for honeycomb panels}$$

Where

$$Z = \frac{\pi^2}{b} \frac{\left(D_{11}D_{22}\right)^{1/2}}{b^2u}$$

$$B_3 = \frac{D_{66}}{\left(D_{11}D_{22}\right)^{1/2}}$$

$$B_1 = \left(\frac{D_{22}}{D_{11}}\right)^{1/2}$$

$$u = G_c^1 (c + t_f) \tag{93}$$

The compressive buckling loads are predicted by the following equations. For advanced composite plates:

$$N_{xcr} = \frac{2\pi^2}{b^2}\left[\left(D_{11}D_{22}\right)^{1/2} + D_{12}\right] \tag{94}$$

For advanced composite wide columns:

$$N_{xcr} = \frac{\pi^2}{b^2} D_{11} \tag{95}$$

For honeycomb panel plates:

$$N_{xcr} = K_T \frac{\pi^2}{b^2} \left(D_{11}D_{22}\right)^{1/2} \tag{96}$$

Where

$$K_T = \frac{\left[C_1B_1 + 2(B_1\nu_{xy} + 2B_3) + \frac{1}{C_1B_1} + AZ\left(1 + \frac{1}{C_1}\right)\right]}{\left[1 + \frac{Z}{C}\left(C_1B_1 + B_3(1 + C_1) + \frac{1}{B_1} + ZA\right)\right]}$$

$$A = 1 - 2B_2 + B_3[B_1(2C_1\nu_{xy})] + 2B_3 + \frac{1}{C_1B_1}$$

$$B_2 = 2B_3 + \nu_{xy}B_1$$

$$C_1 = \frac{a^2}{Nb^2}$$

Z, B_3, B_1, and u are as defined previously

C_1 is the aspect ratio of the plate divided by the mode. K_T must be minimized with respect to C_1.

For honeycomb panel wide columns:

$$N_{xcr} = \frac{\pi^2}{b^2} D_{11} \left[\frac{1}{1 + \left(\frac{\pi^2 D_{11}}{b^2 u} \right)} \right] \tag{97}$$

Stringer Columns. Covers for the multirib designs can be analyzed for one of four types of integral stiffener configurations - "I", "Z", "T", or hat. These stringers are assumed to be made up of integer number of 0-degree plies only. Stringer sections are sized first for strength requirements, then for local stability of flanges and webs, and finally for column stability requirements. Local stability requirements for stringers are expressed in terms of (b/t) required from Equations 98 and 99; for the applied stresses on the stringer, from Equation 100.

For outstanding flanges:

$$(b/t)\ \text{reqd} = \left[\frac{K_1\, G_{LT}}{fc} \right]^{1/2} \tag{98}$$

For webs:

$$(b/t)\ \text{reqd} = \left\{ \left[\frac{k_2 \pi^2}{12 fc} \right] \left[(Q_1 Q_2)^{1/2} + Q_3 + 2GLT \right] \right\}^{1/2} \tag{99}$$

Where

K_1 and K_2 are buckling constants, 1.0 and 2.0, respectively:

$$fc = \text{Applied stress} = \frac{P_{str}}{A_{str}} \tag{100}$$

P_{str} = Applied load

A_{str} = Stringer area

The stringer load is determined from the strain compatibility relationship between the skin and stringer elements (Equations 101, 102 and 103). The skin element of the column section is made up of 1, m, and n plies, each combination resulting in different elastic properties (Equation 104). The stringer element, however, consists only of l-plies, so its modulus of elasticity is Q_1. The distribution of cover load between the elements is computed for any instance where ply makeup of the skin or stringer is changed.

Also, since the elastic properties of the skin is dependent on m-ply sets, skin stability is always checked to insure proper proportions of skin plies. L-ply fiber stresses for both skins and stringers are checked for compression and tension strength, since any change in load distribution may result in load magnitudes exceeding the ultimate allowables for one element. In the programmed logic, stringer area is varied until both the skin and stringer are within ultimate strength allowables and the skin is stable for combined compression and shear loading.

Load distributions are computed for an assumed skin laminate consisting of 1, m, and n plies and known stringer area, A_{str}, and spacing b_{str}. For equal strains,

$$\frac{P_{sk}}{(A_{sk}\ E_{sk})} = \frac{P_{str}}{(A_{str}\ E_{str})} \tag{101}$$

Where

P_{sk} and P_{str} are the skin and stringer loads, and

$P_{sk} + P_{str} = P = N_x \cdot b_{str}$

A_{sk} = Skin area = $2t_L\ (1 + 2m + n) \cdot b_{str}$

E_{sk} = Elastic modulus of skin laminate

E_{str} = Q_1

Then

$$P_{sk} = P_{str}\left(\frac{A_{sk}\,E_{sk}}{A_{str}\,E_{str}}\right) = P_{str}\,R$$

$$P_{sk} = (P - P_{sk})\,R$$

$$P_{sk} = P\left(\frac{R}{(1+R)}\right) \tag{102}$$

$$P_{str} = P - P_{sk} \tag{103}$$

The elastic modulus of the skin in the xy-plane, E_{sk} is derived as follows:

$$E_{sk} = \frac{1}{t_{sk}}\left[E_{11} - \frac{E_{12}^{\,2}}{E_{22}}\right] \tag{104}$$

Where

$$E_{11} = \frac{2t_L}{t_{sk}}\left[\ell Q_1 + 2m\,Q_4 + n\,Q_2\right]$$

$$E_{12} = \frac{2t_L}{t_{sk}}\left[\ell Q_2 + 2m\,Q_4 + N\,Q_1\right]$$

$$E_{22} = \frac{2t_L}{t_{sk}}\left[(\ell + n)\,Q_3 + 2m\,Q_5\right]$$

The allowable (b/t) for flange and webs, along with physical constraints on minimum and maximum dimensions and minimum number of stringer 1-plies, are used to proportion the total developed 1-ply length implied in the A_{str} value into a stringer section. This results in stringer geometry dimensions for b_f, b_w, and t_{str}, satisfying requirements for (P/A), (b/t), and t_{min} gage. With these dimensions, the sectional inertia properties of the stringer can be computed and final determination made for the allowable column length, L_{rib}, of the skin/stringer column.

$$L_{rib} = \left[\frac{C\pi^2 D_{col}}{N_x}\right]^{1/2} \tag{105}$$

where

C = Column fixity factor

D_{col} = Section stiffness parameter defined as follows

$$D_{col} = \frac{I_{str}\,Q_1}{b_{str}} + \frac{t_{sk}^3\,E_{sk}}{12} + \bar{t}_{str}\,Q_1\,(\bar{y}_{str} - \bar{y}_p)^2 + t_{sk}\,E_{sk}\,\bar{y}_p^2 \tag{106}$$

Where

$\bar{y}_{str}$ = Distance between stringer section centroid and inner surface of skin

$\bar{y}_p$ = Distance between total load centroid point and skin load plane as derived as follows:

$$\bar{y}_p = \frac{\bar{t}_{str}\,Q_1\,(\bar{y}_{str} + t_{sk}/2)}{(\bar{t}_{str}\,Q_1 + t_{sk}\,E_{sk})} \tag{107}$$

Stringer columns with allowable lengths less than the minimum required rib spacing are not accepted. These sections are revised by additions of integer numbers of stringer l-plies. These additional stringer areas increase the section equivalent EI and reduce the average applied load intensities.

<u>Full-depth Honeycomb Sandwich</u>. Full-depth honeycomb sandwich face sheets are sized initially for strength requirements - ℓ-plies for tension and compression loads, and m-ply sets for shear loads. The skin-core combination is then checked for core wrinkling and crushing using Equations 104 and 105.

Core wrinkling:

$$F_{cw} \geq \frac{N_x}{t_{sk}}$$

$$F_{cw} = 0.43\,\left[E_c'\,G_c'\,E_B\right]^{1/3} \tag{108}$$

where

E'_c = Core elastic modulus

G'_c = Core shear modulus

E_B = Skin elastic modulus derived as $E_B = (E_{11}E_{22})^{1/2}$

$$E_{11} = \frac{2t_L}{t_{sk}} (\ell Q_1 + 2m Q_4 + n Q_2)$$

$$E_{22} = \frac{2t_L}{t_{sk}} (\ell Q_2 + 2m Q_4 + nQ_1)$$

Core crushing:

$$P'_c \geq P_{cr}$$

$$P'_c = 2.31 \left(\frac{\rho'_c}{\rho_f} \right)^{1.464} \frac{F_{cy}}{D'^{\,0.16}_{ave}} \tag{109}$$

where

P_{cr} = Crushing load on core

ρ'_c = Core density

ρ_f = Core foil density

F_{cy} = Compression yield stress of the core foil

The crushing load P_{cr} is computed using Equation 110.

$$P_{cr} = \frac{2N_x^{\,2}}{t_{sk}\, E_{11}\, D_{ave}} \tag{110}$$

The programmed synthesis logic in subroutine ACWFDH and CKSFDH includes three options for determining design requirements of full-depth honeycomb sandwich torque boxes. These include:

1. Sizing skin requirements so that the sandwich structure will be stable for specified core type and densities

2. Sizing skin laminates to strength requirements and determining required core densities to satisfy stability requirements

3. Sizing for optimum skin/core combinations to satisfy strength and stability requirements

In cases 1 and 3, skin stiffness increases are made by additions of m-ply sets only. When core densities are varied during optimization, the input core density is treated as the minimum. When densities are changed, E'_c and G'_c values are computed using Equations 111 through 113.

$$E'_c = 2.13 \left(\frac{\rho_c}{\rho_f}\right)^{1.415} E_c \qquad (111)$$

For

$$\left(\frac{\rho_c}{\rho_f}\right) < 0.0338$$

$$G'_c = 2.43 \left(\frac{\rho'_c}{\rho_f}\right)^{1.54} G_c \qquad (112)$$

and for

$$\left(\frac{\rho'_c}{\rho_c}\right) \geq 0.0338$$

$$G'_c = 0.40 \left(\frac{\rho_c}{\rho_f}\right) Gc \qquad (113)$$

E_c = Core foil modulus of elasticity

G_c = Core foil shear modulus

Temperature-dependent properties of the core are based on foil material properties which are computed for each design condition. At-temperature values for E_c, G_c, and F_{cy} are derived from temperature variation data for the foil material, using the same methods described for lamina properties.

General Procedures

At each of the 11 structural analysis stations, torque-box material requirements are synthesized for the five major elements - upper cover; lower cover; front spar; rear spar; and intermediate spars, ribs, or honeycomb core (Figure 41). The covers and spar caps are sized to reach the spanwise bending moment, $M_{x\Lambda i}$. Spar webs are designed to resist the vertical shear load, V_i. The torsional Moment, $M_{y\Lambda i}$, is resolved into web shear loads resisted by the upper skin; lower skin; front spar web, and rear spar web.

In general, the synthesis procedures are similar to that used for metallic designs. The following list summarizes the major differences between them which are primarily due to assumptions made for analysis of advanced composite structures:

1. Only longitudinal fibers (0-degree plies) resist axial loads, and cross fibers (±45-degree plies) resist shear loads.

2. All plies contribute to laminate panel stability.

3. Skin material requirements are analyzed for axial loads and panel stability requirements due to combined effects of inplane axial and shear loads.

4. Skin and spar webs are designed to resist torque shear loads. Intermediate spar webs are assumed to react part of the vertical shear loads.

5. Laminates are synthesized with integer number of lamina. Minimum plate thicknesses are based on requirements for a balanced symmetric system, eight lamina layers consisting of two each of 0-, +45-, -45-, and 90-degree plies. Thickness increases are made by additions of two 0- or 90-degree plies, or two each of ±45-degree plies only, or combinations of all. For honeycomb panels, laminate plies are assumed to be equally divided between the inner and outer face sheets.

6. Addition of ±45-degree plies only are made to increase stiffness levels of panels with inadequate stability stress allowables.

7. Addition of ±45-degree plies only are made to torque-box webs to increase section stiffness to levels required to satisfy torsional stiffness requirements.

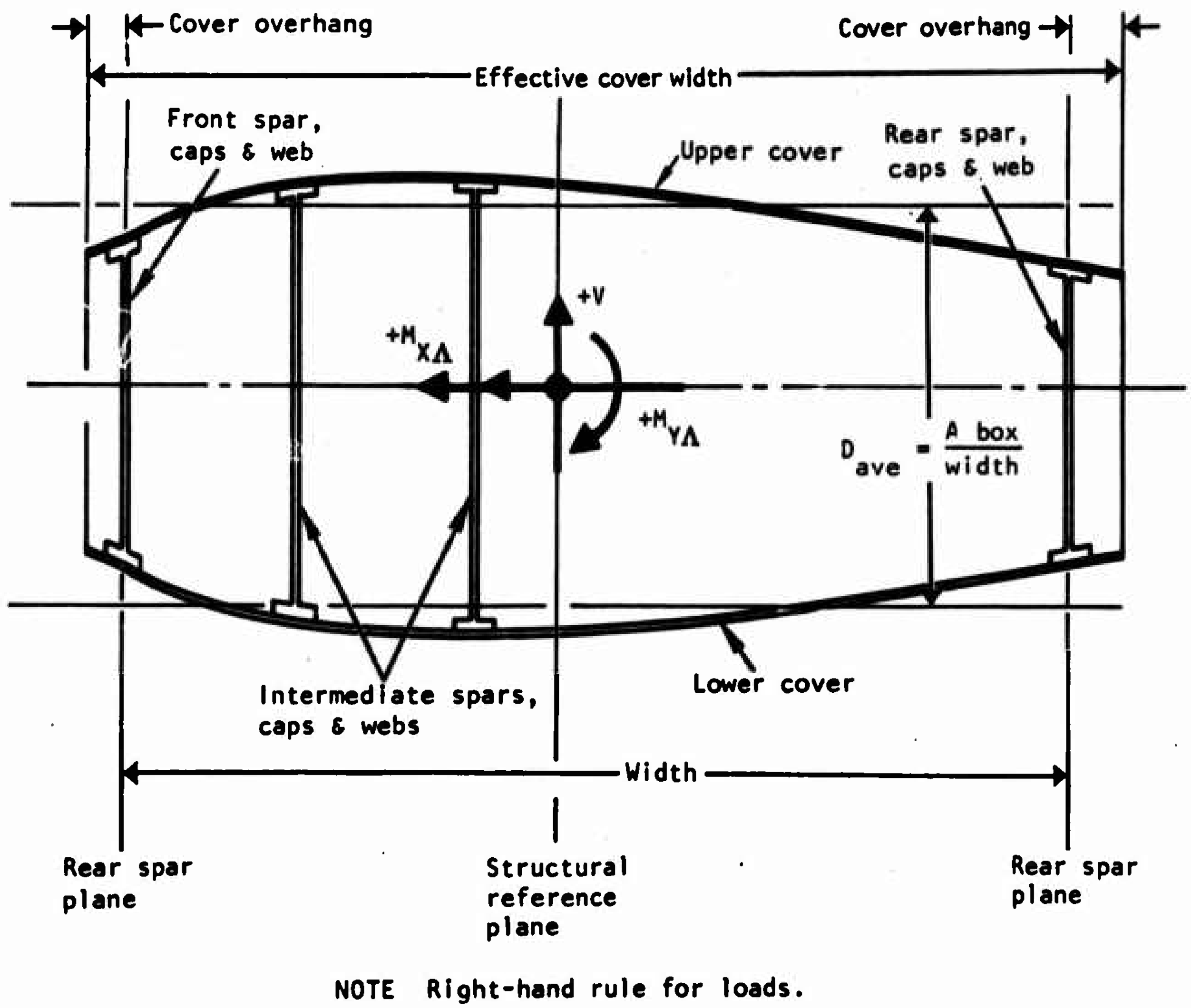


Figure 41. Torque-box cross section.

8. Different stringer concepts can be specified for the upper and lower covers. However, the spacings or number of elements in each cover will remain the same.

9. Stringer areas consist of 0-degree longitudinal plies only. The synthesis procedures for determining allowable stresses and cover material distributions are programmed to include evaluation of load distribution between skin and stringer elements, based on strain compatibility relationships.

10. Spar/rib web synthesis includes analysis for honeycomb panel designs, as well as corrugated web designs.

11. The covers are assumed to be mechanically attached to ribs and spars. Cover lamina are assumed to be rearranged locally along attachment lines to include filler material, replacing relocated 0-degree lamina, for attachment hole drilling.

12. Lightning protection material (aluminum flame spray) is assumed for all exterior surfaces. Provisions are made for application of sealer films to all interior surfaces.

Up to 20 sets of design loads can be evaluated. Strength and stability requirements are determined for the critical applied loads based on allowable stresses derived from at-temperature material properties. The critical design condition for strength is identified by the design condition number, 1 through 20, for each of the five elements. If the structure is subsequently resized to stability requirements, that design condition is also identified by code, the value computed as the condition number plus 20.

Bending loads are resolved into axial compression and tension load intensities, N_x, for cover design. In addition, shear loads, N_{xy}, are computed for skin design using Equation 114.

$$N_{xy_i} = \frac{M_{y\Lambda i}}{2\ A_i} \tag{114}$$

Initially, integer number of ℓ-plies are computed for each cover from the N_x values and ultimate allowable compression or tension stresses. N_{xy} and shear allowable stresses are used to compute the number of m-ply sets required for strength. All loading conditions are processed to determine the minimum number of plies. The number of n-plies are then computed

(Equation 73). The cover skin panels are then checked for panel stability under application of the compression and shear loads for each design condition:

$$R = R_x + R_{xy}^{\;2} \tag{115}$$

where

$$R_x = \frac{N_x}{N_{xcr}}$$

$$R_{xy} = \frac{N_{xy}}{N_{xycr}}$$

If the sum of the ratios, R, is greater than 1, the panel is unstable. To correct this situation, one m-ply set is added to the panel and rechecked. This procedure is repeated until the panel becomes stable for all design conditions. Number of n-plies are always computed after addition of m-ply sets.

Spar web shear loadings are determined with Equations 116, 117, and 118.

Intermediate spars, as required:

$$N_{xy_i} = \frac{V_i}{N_{spar_i} \cdot D'_{ave_i}} \tag{116}$$

Front Spar:

$$N_{xy_i} = C_{FS_i}\left(\frac{V_i}{N_{spar_i} \cdot D'_{FS_i}}\right) + \frac{M_{yA_i}}{2A_i} \tag{117}$$

Rear Spar:

$$N_{xy_i} = C_{RS_i}\left(\frac{V_i}{N_{spar_i} \cdot D'_{RS_i}}\right) - \frac{M_{y\Lambda_i}}{2\,A_i} \tag{118}$$

Where

N_{spar_i} = Number of intermediate spars + 2

C_{FS_i} and C_{RS_i} = Front and rear spar shear load magnification constants involving two items; an input set of 11 constants for each spar, and a shear load reaction factor based on location of load reference line relative to spars

These shear loads are used to determine the initial number of m-ply sets in each web. L-plies are based on spar crushing loads determined from cover stiffness, load intensities, and local geometry parameters (Equation 119).

$$P_{cr_i} = \frac{2\,N_{x_i}^{\,2}\;b_i}{t_i\,E_{c_i}\,D'_i} \tag{119}$$

Where

$$E_{C_i} = \frac{2t_L}{t_i}(\ell Q_1 + 2mQ_4 + nQ_2)$$

$$t_i = 2t_L(\ell + 2m + n)$$

b = Spar spacing

D' = Web depth

The stability of each web under the combined effects of applied N_{xy} and P_{cr} loads are checked. If required, m-ply sets are added to stabilize the structure.

Intermediate rib webs are designed for strength and stability requirements due to crushing loads only. Equation 120 is used to compute crushing loads on ribs.

$$P_{cr} = \frac{2\, N_x^2\, L_{rib}}{(t_{sk} \cdot E_{sk} + \bar{t}_{str} \cdot Q_1) \cdot D'_{ave}} \tag{120}$$

Where

L_{rib} = Rib spacing

t_{sk} = Skin thickness

$\bar{t}_{str}$ = Equivalent stringer thickness, $\frac{A_{str}}{b_{str}}$

E_{sk} = Skin elastic modulus

The number of m-ply sets is assumed to be one before stability checks are made. The rib is then checked for rigidity as supports for the cover stringer column under compression loads. The required web stiffness is expressed in terms of EI required for the web from Equation 121. This requirement is assumed to be at the midpoint of the rib about an axis normal to the plane of the rib. Thus, in computing available stiffness, the ℓ and n plies are interchanged in Equation 122. Also, the available rib inertia, I_{rib}, include effects of 1-inch-wide upper and lower caps:

$$EI_{reqd} = \frac{N_x W_i^4}{125.0\, L_{rib}} \tag{121}$$

Where

W_i = Torque-box width

$$E_{rib} = \frac{2\ t_L}{t_{rib}} (nQ_1 + 2mQ_4 + \ell Q_2) \tag{122}$$

$$I_{rib} = \frac{1}{12}\ t_{rib}\ D'^3_{ave} + \frac{1}{2} t_{rib}\ D'^{\,2}_{ave} \tag{123}$$

If the available rib EI is insufficient to satisfy Equation 121, m-ply sets only are added to the web.

Multispar Analysis

A single-level optimization search procedure is used for the synthesis of multispar torque boxes. The total torque-box weight is optimized with respect to the number of cover support elements - intermediate spar webs. The search parameter is dependent upon the option selected, i.e., constant number of elements, NOS, or constant spacings of webs, b_s, from root to tip. The search loop is designed to select the single value of NOS or b_s that will produce the minimum torque-box weight. Search parameter value checks are made so that NOS and b_s are constrained between minimum and maximum values. These limit values, which can be controlled by the user, insure that resulting sizings will reflect practical producible designs. Subroutine ACWMS is used for optimization control and required analysis of multispar designs.

Design values for intermediate spar spacings or number of elements at each station is specified during each analysis pass by the control routine. This determines the unique cover plate dimensions between supports, b_s, that are different in each analysis pass. Cover and web loads are computed based on this value. Each major torque-box element is then sized to strength and stability requirements. Plate width for cover stability evaluated is based on b_s. Local depths, adjusted for cover plates and cap thickness allowances are used for the height dimension in the web stability analysis.

Total torque-box is initially sized for strength and stability under the imposed design loads. Total weight computed at each station consists of the five major elements, upper cover, lower cover, intermediate spar caps and webs, front spar caps and web, and the rear spar caps and web. Miscellaneous items are also included in the weight computations, particularly the items that are dependent upon the number of spar web elements. These include the mechanical attachment provisions at cover-spar joints, spar web protective finish, and honeycomb core and bond weights for honeycomb panel spar designs.

Torque-box weight per inch computations are made by subroutine WEIGH1. These are used by ACWMS to compute weights for the 10 torque-box panels. The sum of these panel weights is used during the testing procedures for selection of the optimum design.

Subroutine WEIGH1 also computes weight for full-depth honeycomb sandwich designs. ACWMS acts as the control routine for this type of analysis. In the programmed logic, ACWMS uses full-depth honeycomb sandwich analysis subroutines ACWFDH and CKSFDH to compute cover and core requirements only. Front and rear spar analysis is common to both design types.

Torsional stiffness computations are made and flutter stiffness checks and resizings made as required after the optimum design is selected. Detail information at each station pertinent to the selected design are processed and saved by the computing routines. The design information is further processed by subroutine ACNSTR and stored in appropriate storage cells so that final estimated weights can be computed by the same weight analysis subroutines written for the metallic analysis, namely WTCAL, WTPIN, BHDJT, RTRIB, and CSECW. The design information is also processed by ACNSTR for output print by subroutines PRTB, PRTC, and ACPRTA.

Construction options which may be selected for multispar designs include plate and honeycomb panels for the cover and support webs. The selected option for cover design is used for both upper and lower covers. If honeycomb panel design is selected, the panel core thickness for both covers must be specified.

Construction design for each of the three web types is specified individually. Plate design implies corrugated sine-wave configuration. The corrugation radius for each web type may be controlled by the user by specifying minimum and maximum values. If honeycomb panel is selected, the panel core thickness must be specified for each web type.

In all honeycomb panel designs, the specified core thickness is used at each analysis station. Core and bond densities are also assumed to be constant at each station and for all five elements.

Multirib Analysis

The multirib optimization procedure requires two major search levels. The first level consists of optimization of a number of stringer elements in the compression cover, similar to the number of spar element search in multispar analysis. The second level consists of determination of the best combination of 1-plies in the skin panels that will result in minimum cover and support weight at each analysis station. Overall control for the analysis is centered in subroutine ACWRBS. Logic for the first-level search and station analysis control is programmed in this subroutine. The second-level search control is programmed in subroutine ACWSTR. Special analysis subroutines ACMRSK and ACSTRG are used to provide required data to ACWSTR. These subroutines are used during secondary search computations nested within the overall skin 1-ply search logic. Figures 42, 43, and 44 show the logic and computation flow for the multirib analysis.

The rationale for the logic programmed in subroutine ACWSTR (Figure 43) is that, for each assumed number of 1-plies in the skin, there is one skin m-ply plus stringer area set that will satisfy all conditions of strength and stability for the skin, stringer and skin/stringer column resulting in a minimum total volume required for cover and supporting ribs. The compatibility equations for all the conditions do not allow for direct solutions; rather, a numerical search procedure is programmed in subroutines ACWSTR, ACMRSK, and ACSTRG, all based on the initial assumption that only integer number of filament plies will be considered in the sizing computations.

The ACWSTR computations for stringer area are all made for a given skin 1-ply valve. Stringer area is sized first for ultimate stress conditions. This search requires the determination of that stringer area that will result in maximum applied tension or compression stress on the skin or stringer element that is equal to or below the allowable ultimate stresses. The element load/skin stability computations programmed in subroutine ACMRSK provides the necessary data for this search. For each assumed stringer area, subroutine ACMRSK determines skin m- and n-ply requirements as well as the skin and stringer loads P_{sk} and P_{str}. The numerical search procedure is used here since the load distribution and stability equations are implicitly related. Also, the requirement of evaluating up to 20 N_x and N_{xy} load sets (the N_x loads being either compression (+) or tension (-)) adds to the complexity of the solution. The loads P_{sk} and P_{str} plus the number and widths of 1-plies in the stringer allow for computations of the applied stress levels. These values are checked by subroutine ACWSTR to determine acceptable stringer areas.

Subroutine ACWSTR then determines if the stringer section can be proportioned into acceptable geometries to conform to the type of stringer specified for the cover and the crippling requirement dictated by the minimum (b/t). Subroutine ACSTRG performs the necessary test and

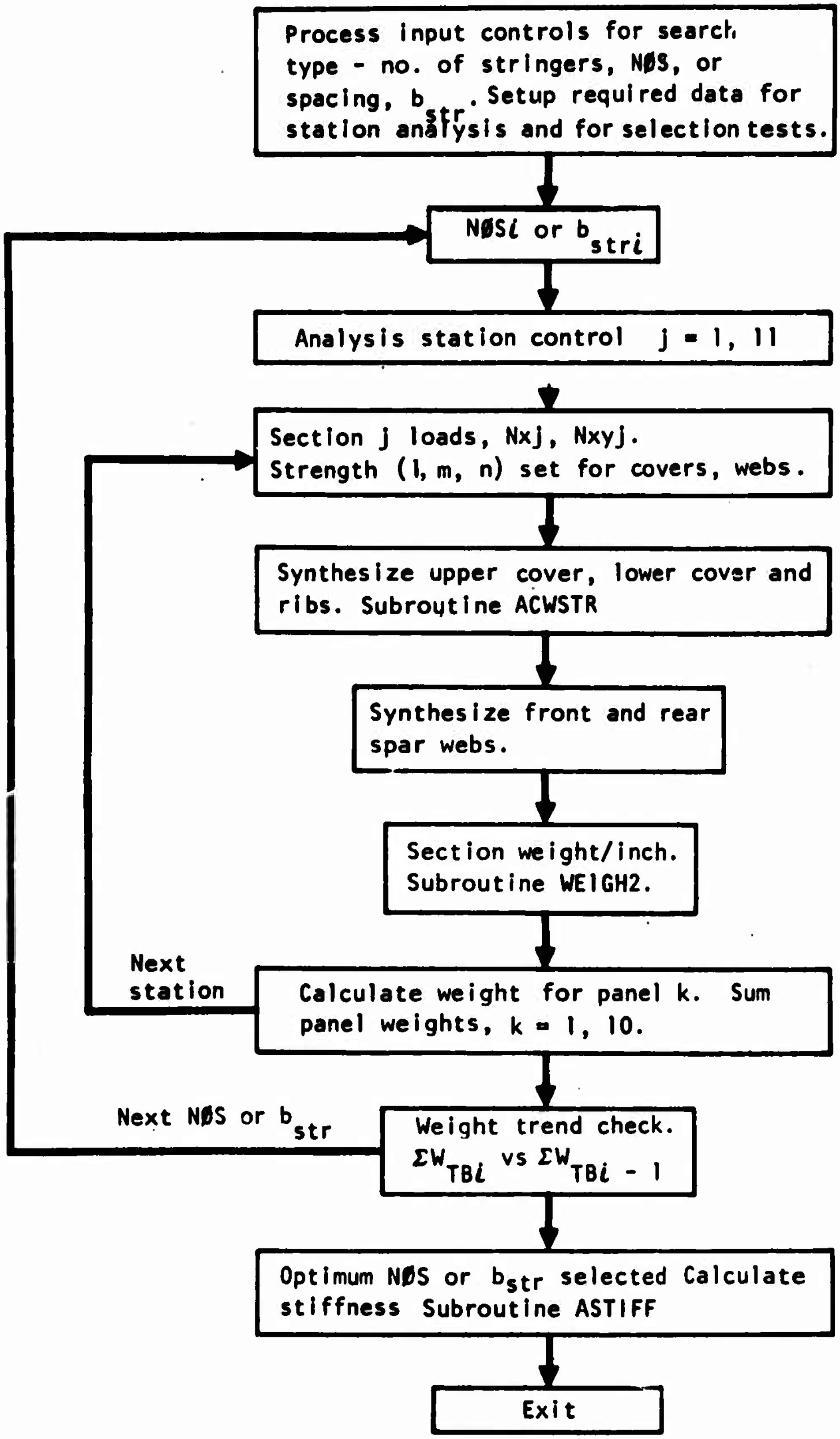


Figure 42. Logic and computational flow diagram for total multirib torque-box optimization, subroutine ACWRBS.

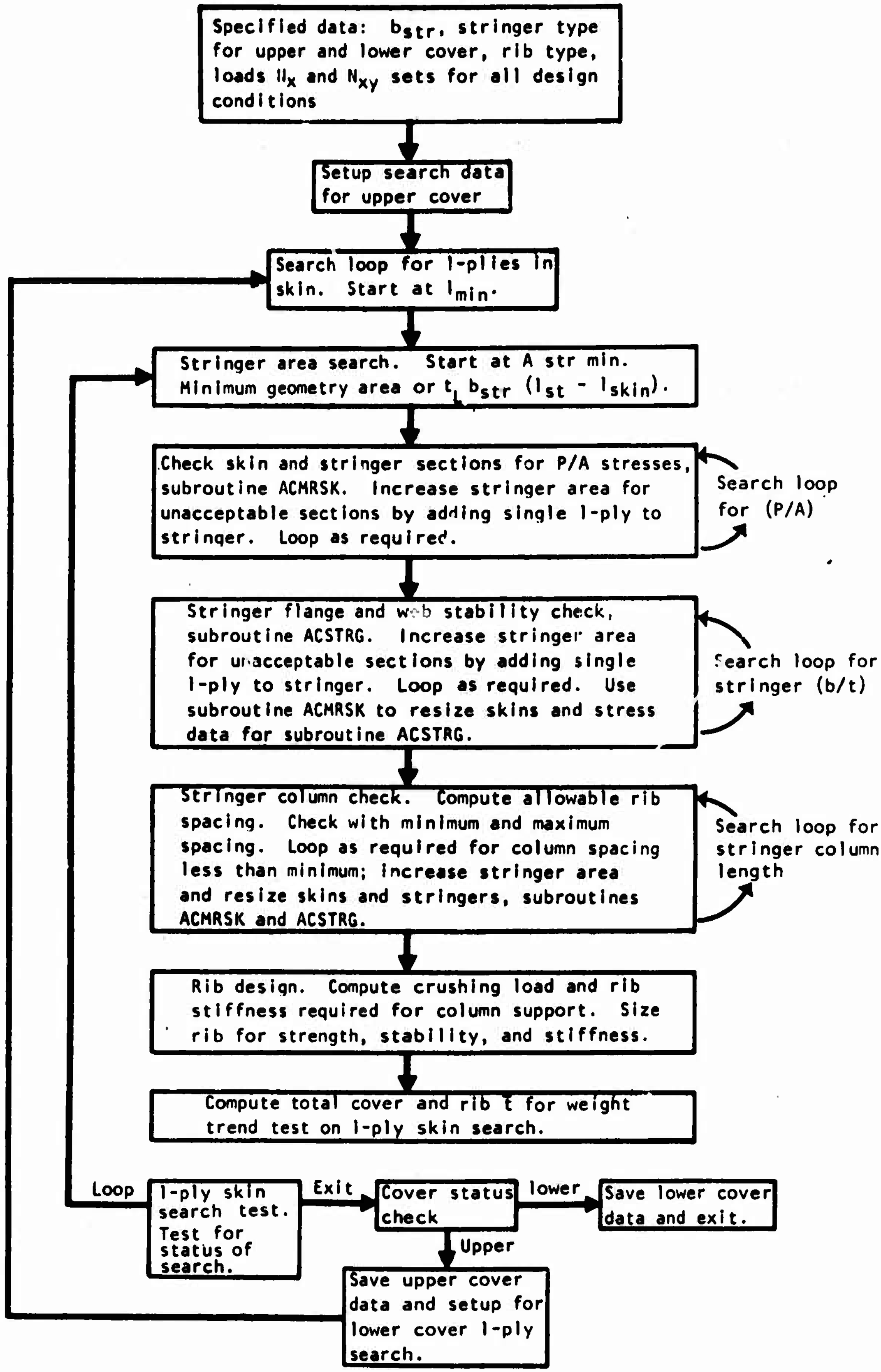


Figure 43. Logic and computational flow diagram for synthesis of stringer stiffened covers, subroutine ACWSTR.

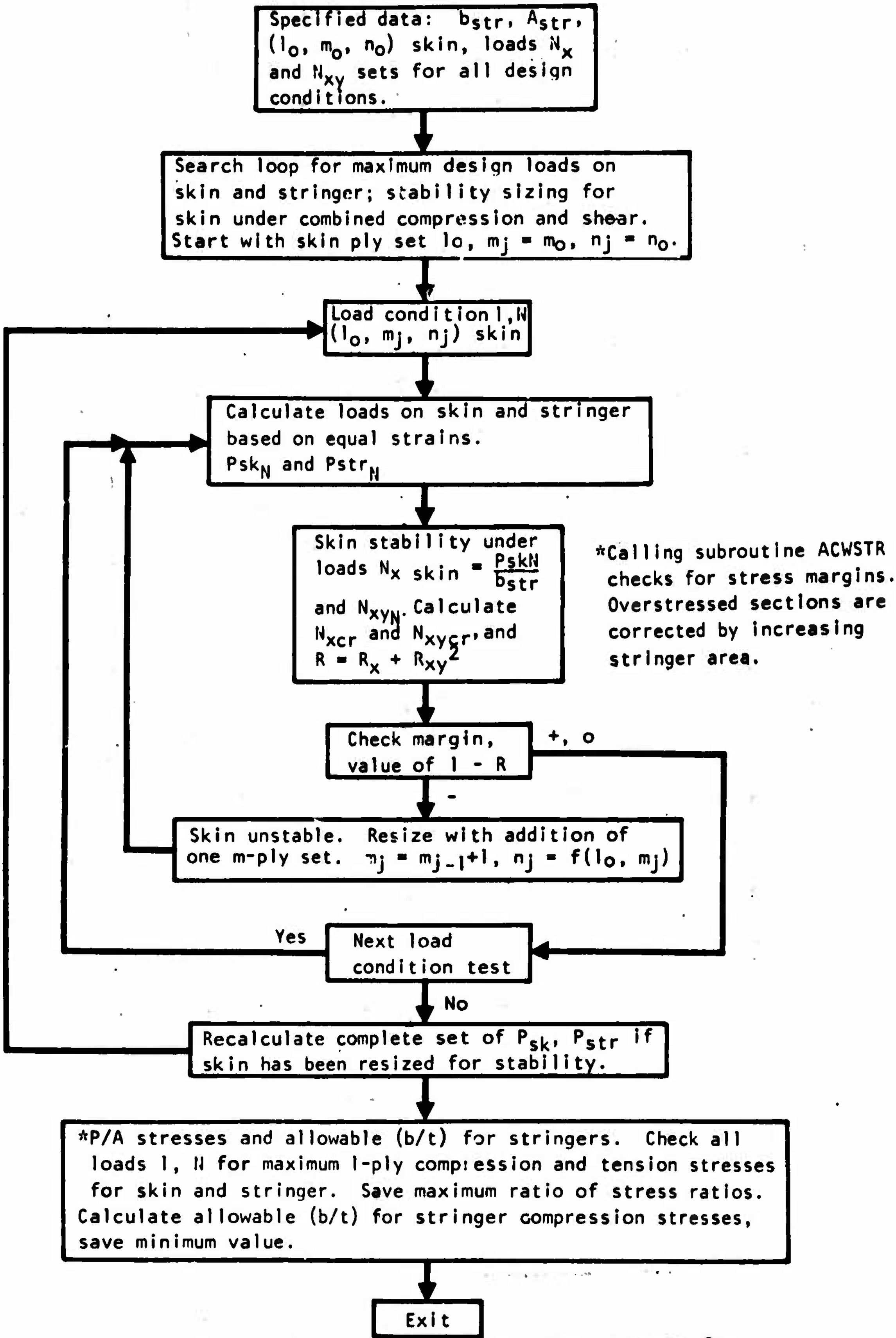
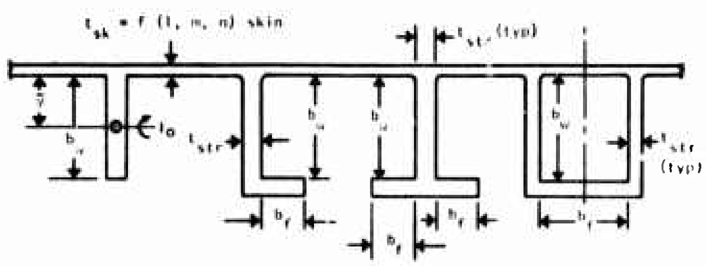


Figure 44. Logic and computational flow diagram for skin/stringer load and skin stability, subroutine ACMRSK.

proportioning operations. Unacceptable sections are identified by code. Acceptable sections are optimized to develop maximum stringer area moment of inertia by maximizing stringer heights. Stringer section properties are computed by ACSTRG to be used by ACWSTR in the skin/stringer column rib spacing search operations.

Stringer types are identified by code word associated with specific shapes (Figure 45). The number of webs and flanges, N_h and N_f, for each shape are used in the general equations used to compute areas, developed length for stringer 1-plies, and/or stringer gages, t_{str}.

The stringer centroid, $\bar{y}$, is referenced to the inner mold line of the skin, and section inertia, I_o, is computed about the centroid using standard equations for these properties.



Type:	I	Z	T	Hat
Code:	(1)	(2)	(3)	(4)
N_h	1	1	1	2
N_f	0	1	2	1
N_t	0	1	1	2

General equation for area, $A_{str} = t_{str}\left[N_h b_w + N_f b_f + N_t t_{str}\right]$

$t_{str} = t_L l_{str}$

Figure 45. Stringer types for multirib torque-box covers.

The ACWSTR logic is programmed to synthesize the tension cover after the compression cover configuration and rib spacing have been determined. The tension cover synthesis pass uses the same logic programmed for the compression cover. Cover status code word is used to identify which cover is being analyzed so that results are stored in appropriate storage locations.

The logic and subsequent computations made by ACWRBS is the same as programmed in subroutine ACWMS. Torsional stiffnesses are computed and computed design information is processed by subroutine ACNSTR into the appropriate format for final processing into estimated weights.

Bending and Torsional Stiffness

Torque-box stiffness at each station is estimated based on procedures similar to those used in the metallic analysis. For output evaluation of stiffnesses, a reference design temperature is specified so that computed EI and GJ at all stations are compatible. Three additional stiffness computations are made as required. These are made at analysis temperatures specified for flutter design and at the design points for flexible loads and flutter optimization analysis.

In all cases, EI's and GJ's are computed for the final lamina sets resulting, first, from strength and stability sizings and, second, from the results of the flutter stiffness analysis. The torque-box elements considered in the stiffness computations are listed in Table 15. The applicable elastic modulus for each element is noted.

TABLE 15. TORQUE-BOX ELEMENTS, SECTION STIFFNESS CALCULATIONS

Torque-Box Element	Bending Stiffness		Torsional Stiffness
	EI	E	GJ
Upper cover skins	✓	a	✓
Lower cover skins	✓	b	✓
Intermediate Spar caps, multispar	✓	a,b	-
Stringers, multirib	✓	c	-
Cover overhang at spars, upper	✓	a	-
Cover overhang at spars, lower	✓	b	-
Front and rear spar caps, upper	✓	a	-
Front and rear spar caps, lower	✓	b	-
Front spar web	-	-	✓
Rear spar web	-	-	✓

Equations for E:

a. $\frac{2t_L}{t}(\ell Q_1 + 2mQ_4 + nQ_2)$ upper

b. $\frac{2t_L}{t}(\ell Q_1 + 2mQ_4 + nQ_2)$ lower

c. E_L

The section stiffness is derived as the sum of the stiffness contribution of each element (Equation 124, or 125. The effective moduli E and G are determined separately for each element from Equations 75 and 76 based on the final values of l, m, and n. Equivalent composite E' and G' values are computed by dividing the calculated EI and GJ values by the sum of the I's

and J's for the section (Equations 126 and 127). These values are printed as output along with the stiffness values to be used as order of magnitude information.

$$EI = \sum E(Ay^2 + I_o) \tag{124}$$

$$GJ = \frac{4A^2}{\sum \frac{ds}{tG}} \tag{125}$$

$$E' = \frac{(EI)}{\Sigma I} \tag{126}$$

$$G' = \frac{(GJ)}{J} \tag{127}$$

For strength-designed sections that must be resized to meet flutter stiffness requirements, integer number of m-ply sets are added to the four-webs contributing to the section torsional stiffness. Added m-ply sets are made to the thinnest web first until the thickness of this web is equal to the next thinnest web or the required stiffness level is met. Additional plies are added in an ordered manner so that, in the extreme case, the four webs will consist of ply sets producing equal thickness webs. The 1- and n-ply values are not adjusted.

Section stiffness computations are made under control of subroutine ASTIFF. This subroutine is designed to process synthesis information for all three major construction types - multispar, multirib, and full-depth honeycomb sandwich.

PIVOT STRUCTURE SYNTHESIS

A first-level wing pivot structure synthesis routine has been programmed as a subroutine of the weight estimating program. The pivot system analysis is restricted to the vertical pin type, utilizing a straight Teflon-lined bearing. The program is designed so that the basic pivot weight estimate is optimum for the particular set of design data specifications. The necessary external data required include the spanwise and chordwise location of the pivot, and material. The synthesis results will include weight estimates for the movable and fixed lug structures as well as the pin, bearing, and lug support structures. Design data for the pivot such as lug widths, pin diameters, bearing depths, and design loads will be available from the results of the analysis.

WEIGHT ANALYSIS

Weight analysis of lifting surfaces is made by various functional routines of this module. Weights for structural components are evaluated in detail to provide estimates for 9103-D group weight items, detail torque-box elements, and mass properties distributions. Design and descriptive data from the input data sets, structural synthesis routines, and design data routines are all used for mass properties evaluation, which are designed to:

1. Compute weights of structural elements of the main bending box from design data developed by the synthesis routines, and compute pivot and center-section weights, as required.

2. Compute component weights for leading edge, trailing edge, and secondary structures from geometric, statistical, and vehicle design parameters.

3. Determine total structural weights and mass properties distributions for final output or for the next iteration so that calculated structural weight data will be available for net loads analysis.

TORQUE-BOX WEIGHT ANALYSIS

Final estimated weights for the torque box are derived (1) by application of weight indexing coefficients to each of the box elements synthesized and (2) by estimating weights for any required structures at local stations along the span, such as chordwise splices, bulkheads, etc. Table 16 includes a set of program index factors for the torque-box elements of a wing design. These factors applied to the synthesized structures result in a 13.6-percent increase in weight. This nominal increase in synthesized weight results from lower program index factors used during point design studies, since many design constraints are known, and program design data such as geometries, loads, stiffness requirements, etc, can be controlled and preliminary information from the various engineering groups can be used instead of program-generated data. The individual factors will be larger for conceptual phase solutions, because many design data will not be available and program synthesis operations cannot be expected to produce all required structures of an unknown design. Under these conditions, the average single weight factors will be between 25 to 45 percent. This range will be influenced by individual coefficient and sizing changes due to construction, material, and detail design differences.

TABLE 16. SAMPLE WING TORQUE-BOX PROGRAM CALIBRATION AND WEIGHT INDEX COEFFICIENTS

Torque Box Components and Elements	Torque Box	
	Intermediate Panel Multispar	Center-Section Stringer-Rib
Torque Box	1.0050	1.0000
Upper cover	(1.0675)	(1.0925)
Skins	1.0300	1.1172
Stringer/spar caps	1.2140	0.8631
Lower cover	(1.0725	(1.0725)
Skins	1.0450	1.0637
Stringer/spar caps	1.2078	0.9405
Misc skins	(1.2350)	(1.2350)
Misc attachments	(1.0750)	(1.0750)
Intermediate ribs/spar webs	(1.1250	(1.1385)
Basic webs	1.0500	1.0242
Misc	1.0750	1.0970
Front spar	(1.1355)	(1.0400)
Caps	1.1450	1.0400
Webs	1.1450	1.0000
Rear spar	(1.1350)	(1.0400)
Caps	1.1940	1.0970
Webs	1.0970	1.0000
Root rib/CL rib	(1.1450)	(1.0450)**
Caps	0.3330	0.5000
Webs	1.1405	1.5500
Torque box average single factor weight index coefficient	1.1364*	1.1090*

$$*K = \left[\frac{\text{Actual box wt}}{\text{Estimated box wt}}\right]$$

**One rib/air vehicle

The individual element indexing approach is used so that weight increments can be assessed to individual elements for discrete functions and reasons. In this way, load, geometry, and/or design-related increments not considered in the analysis can be isolated and accounted for when unique design requirements must be considered. In general, the weight index factors are determined externally by program calibration runs. These factors must be considered first as analysis calibration factors and, second, as incremental weight factors to be used to assess unique conditions and design parameters not considered in the analysis or indexing operations.

The final torque box weight estimate will include detail weights for each element. These weights are determined by the average end area method of volumetric calculation:

$$W_{element_j} = \frac{\Delta Y_j}{2} \cdot \rho \cdot \left[A_{element_i} + A_{element_{i-1}} \right] \qquad (128)$$

Where

$W_{element_j}$ = the element weight for panel j

ΔY_j = the station interval for panel j

ρ = the material density

$A_{element_i}$ = the total element cross section at the panel stations

The element area at each station is derived from the synthesized equivalent gage, the section width, and the element index factor:

$$A_{element_i} = Width_i \left[\delta_{element} \times \bar{t}_{element_i} \right] \qquad (129)$$

In all cases, the element index factor is not applied to minimum gage material or to skin and web gage increments required to increase section stiffness for flutter.

The program also includes major component factors for the torque box, pivot, center section, leading edge structures, trailing edge structures, secondary structures, and one for the total surface weight to allow single-factor indexing operation.

Since structural sizes are synthesized at 11 stations along the structural chord, local torque box weights per inch and station-to-station panel weights can be estimated. These derived mass distribution data are used for (1) mass properties evaluation of the torque box estimates and (2) to provide detail distribution data for comparisons of materials and constructions, or to determine location and weight increments due to flutter stiffness penalties or changes in general wing geometry and design parameters.

The cover weight at each structural station includes spar overhang material. A structural width correction factor is applied to both upper- and lower-cover skin weights based on the effective width derived from Equation 20. K_{wt}, the weight correction factor, is:

$$K_{wt} = \frac{W_{eff}}{W} \tag{130}$$

Cover stringer and intermediate spar weights are corrected with the factor derived from Equation 130. This accounts for the number-of-elements to number-of-spacings inequality that results from the basic equivalent $\bar{t}$ method of representing cover and intermediate support structures, as discussed previously.

The density ρ, in Equation 128, applied to all torque box $\bar{t}$'s, is the material density of the compression cover. A density correction factor other than 1.0 is applied to the lower-cover and spar weights if the input data set contains specified densities for these structures. This provides for sensitivity to selections of materials or alloys, other than that specified for the compression cover, although the same material is generally assumed for all four major elements. However, some vehicle designs require selections of different types and alloys of aluminum for specific applications and requirements. In general, these selections are based on the unique physical and mechanical properties of specific alloys such as superior strength, fracture toughness, fatigue life, stress corrosion, or elevated-temperature properties.

LEADING AND TRAILING EDGE WEIGHT ANALYSIS

The weight analysis routines for leading and trailing edge structures are designed to provide detailed mass properties descriptions of these components. Weights of each major leading and trailing edge component are estimated with statistical equations based on component geometry parameters and/or vehicle design criteria. These statistical equations provide

structural weight sensitivity to configuration-oriented geometry, environment, and design specifications. Each estimation equation includes design load factor, design gross weight or maximum dynamic pressure, component type, and component physical size parameters from which unit weights for each component are derived.

The basic equations for control surface devices are modified so that the unit weights can be adjusted through specific types of data in the input data set. This allows for weight sensitivity to design-oriented features of the vehicle being evaluated. Each control surface device includes three additional terms, added specifically to increment the basic unit weights for (1) local $t/_c$, (2) local physical available volume, and (3) surface actuation (number of actuation systems per device).

Vehicle criteria and general geometry data are ordered for the analysis routines by the design data module routines of SWEEP or the general lifting surface data control routine of this module. Physical descriptions of the components are derived by the analysis routines from lifting surface geometry data and data subsets in the input data set which are used to describe the physical dimensions and locations of each component.

Control surface device descriptions must specify the type, number of panel segments per device, and pertinent control coordinates so that necessary geometric data can be computed. The generalized procedures discussed under "Lifting Surface Geometry," of this section, are used to specify the boundry lines of any control surface device. Geometry data for each type of device must be provided in specific formats, since estimation procedures for each type are programmed individually. Figure 46 shows wing control surface devices showing the required geometry specifications which are used for device planform geometry area calculations and for positioning the device in the correct location.

Estimation Equation Form

The weight estimation equation can be expressed in general form as:

$$w/s = K_o\left[K_1 + \Sigma\Delta K\right]\left[(w/s)_o\right] \tag{131}$$

Where

w/s = estimated unit weight

K_o = general weight coefficient to be used by the user, 1.0 unless changed

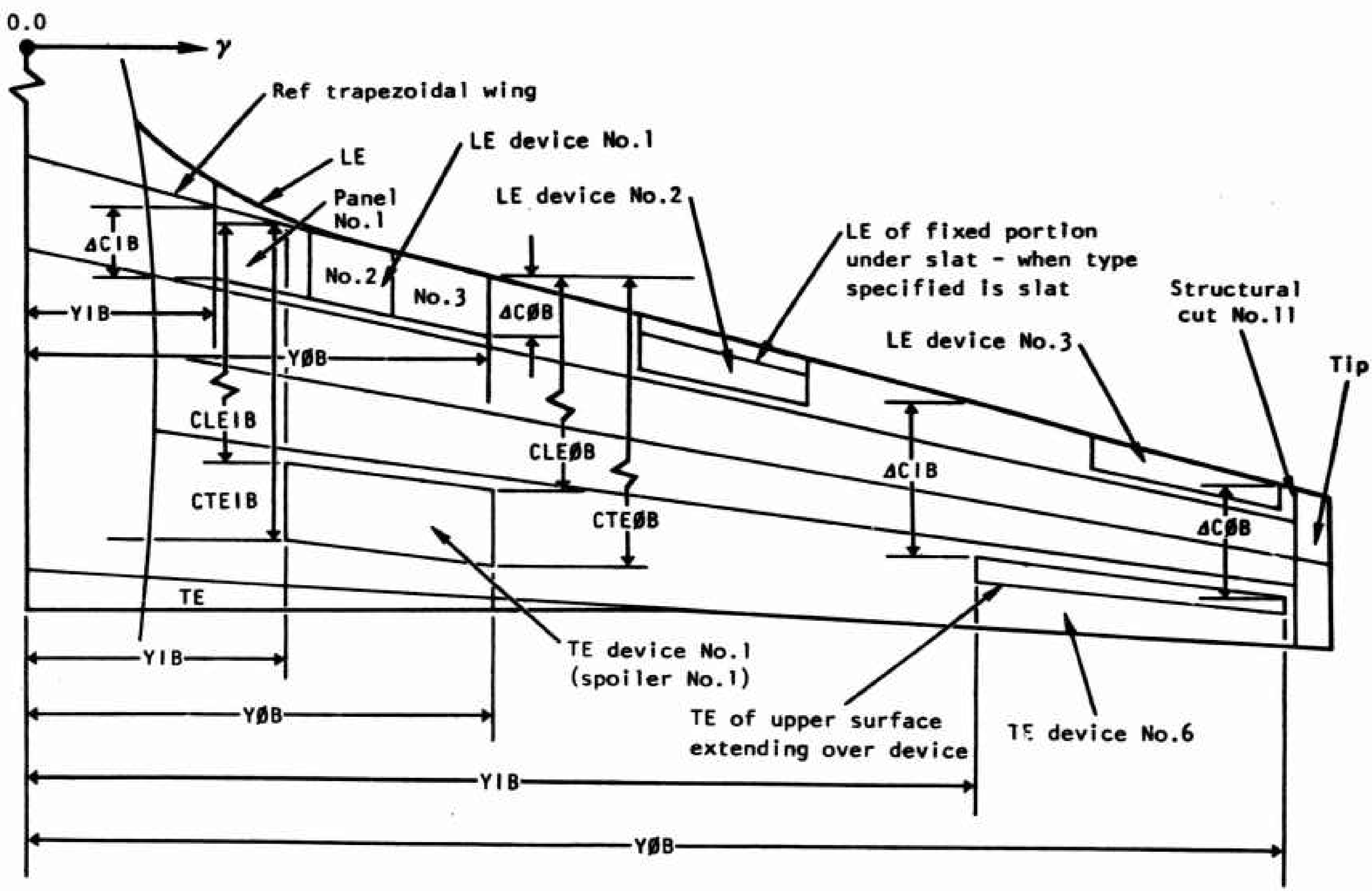


Figure 46. Leading and trailing edge control geometry.

K_1 = basic statistical equation correlation factor, different for all components

$\Sigma\Delta K$ = derived unit weight modification factors

$(w/s)_o$ = basic statistical unit weight (function of vehicle environment and geometry)

For all devices, provisions are made in the input data set and analysis logic to allow the user to specify desired unit weights, in lieu of the program derived data.

The basic statistical unit weight, $(w/s)_o$ is derived for each component in one of the following three forms:

$$w/s = C_1 \ (C_2 X_1 + C_3) \tag{132}$$

$$w/s = C_4 \left(X_2\right)^{C_5} + C_6 \left(X_3\right)^{C_7} \tag{133}$$

$$w/s = C_8 \left(X_4\right)^{C_9} \tag{134}$$

where the C_{1-9} are equation constants, and the X_{1-4} are estimation parameters based on vehicle criteria and component geometry.

The unit weight modification factor $\Sigma\Delta K$ consists of three terms:

$$\Sigma\Delta K = \Delta K_2 \left[\frac{(t/c)_{ref}}{(t/c)_i}\right]^{0.25} + \Delta K_3 + \Delta K_4 \left[N^{0.125} - 1.0\right] \tag{135}$$

where

ΔK_2 = basic incremental factor for thickness ratio

ΔK_3 = basic incremental factor for available volume

ΔK_4 = basic incremental factor for number of actuators

$(t/c)_{ref}$ = 0.10, constant

$(t/c)_i$ = aerodynamic thickness ratio at midspan of each segment panel

N = number of actuators per segment panel

Term 1 of Equation 135 is included in the fixed structure equations.

Fixed Leading Edge Structure

The fixed leading edge structure is assumed to include all structures, other than the leading edge devices, forward of the front spar and between the buttock lines defined by the Y-coordinate at the first and eleventh structural cut. The weight analysis accounts for any structure forward of the theoretical leading edge of the trapezoidal planform. However, the geometric parameters used for evaluation of $(w/s)_o$ are based on the theoretical leading edge geometry. The derived unit weights, based on Equation 132 when multiplied by the true exposed leading edge planform, results in the estimated fixed leading edge weight only if leading edge devices are not specified.

For leading edge designs with control surface devices, fixed structure weights are subtracted from the initial estimates. These incremental weights are computed from assumed fixed leading edge weight distribution surfaces and is dependent upon the type and location of the control surface device. The weight distribution surface is initially determined by assuming that the derived unit weight is distributed uniformly over the exposed leading edge. Thus, panel point weights then can be computed between spanwise leading edge distribution control stations. Each individual panel weight is then assumed to be distributed linearly between the control points as a function of the true aerodynamic chord forward of the front spar. The chordwise distribution of the unit spanwise weight at any station is then assumed to be distributed between the true leading edge and the front spar, based on a predetermined trapezoidal distribution. The surface is evaluated by the procedure described under "Lifting Surface Design Data," of this section.

The estimation equations for $(w/s)_o$ for wing, horizontal, and vertical tails are shown in the following, along with the final unit weight equations:

1. Wing:

$$(w/s)_o = 0.00077 \left[\frac{0.8\, Q_{max}\, S_{le}}{C_{ave}}\right] + 0.83 \qquad (136)$$

$$(w/s)_w = K_w \left\{1.50 + 0.10 \left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25}\right\} (w/s)_o \qquad (137)$$

2. Horizontal tail:

$$(w/s)_o = 0.0004\left[\frac{0.8\ Q_{max}\ S_{le}}{C_{ave}}\right] + 0.54 \tag{138}$$

$$(w/s)_h = K_h \left\{1.75 + 0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25}\right\}(w/s)_o \tag{139}$$

3. Vertical tail:

$$(w/s)_o = 0.0004\left[\frac{0.8\ Q_{max}\ S_{le}}{C_{ave}}\right] + 0.54 \tag{140}$$

$$(w/s)_v = K_v \left\{1.50 + 0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25}\right\}(w/s)_o \tag{141}$$

Where

Q_{max} = maximum dynamic pressure, generally determined at V_L, sea level

S_{le} = exposed theoretical leading edge planform area

C_{ave} = average chord determined by dividing exposed area by exposed leading edge span measured along front spar

$(t/c)_{ave}$ = aerodynamic thickness ratio at exposed leading edge midspan

Leading Edge Control Devices

Three sets of leading edge devices can be positioned on any wing planform, as shown in Figure 46. The device type at each location must be specified from one of three types of leading edge devices: (1) leading edge slats, (2) leading edge kruger flap, and (3) droop leading edge.

The weight estimates are based on unit weights computed for up to three segments per device. The number of segments, specified in the input data set, is used to compute segment geometries that are of equal spans. The total

device weight and centroid are computed from segment data, from which device weight distribution data are computed.

The estimation equation for $(w/s)_o$ and the final segment unit weights follow:

1. Leading edge slats:

$$(w/s)_o = \left[0.551\left(\frac{N_{zult}\ DGW}{S_w}\right)^{0.32} + 1.0\left(\frac{0.8\ Q_{max}\ S_{pnl}}{b_{pnl}}\right)\right]^{0.25} \tag{142}$$

$$(w/s)_{sl} = K_{sl}\left\{1.0+0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25} +0.01+1.0\left[N^{0.125}-1.0\right]\right.(w/s)_o \tag{143}$$

2. Leading edge kruger flaps:

$$(w/s)_o = \left[0.413\left(\frac{N_{zult}\ DGW}{S_w}\right)^{0.32} + 0.667\left(\frac{0.8\ Q_{max}\ S_{pnl}}{b_{pnl}}\right)^{0.25}\right] \tag{144}$$

$$(w/s)_{kr} = K_{kr}\left\{1.0+0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25} +0.01+0.75\left[N^{0.125}-1.0\right]\right\}(w/s)_o \tag{145}$$

3. Droop leading edge:

$$(w/s)_o = \left\{0.00077\left[\frac{0.8\ Q_{max}\ S_{pnl}}{C_{ave}}\right]+0.83\right\}+\left\{0.33\left[\frac{0.8\ Q_{max}\ S_{pnl}}{b_{pnl}}\right]^{0.25}\right\} \tag{146}$$

$$(w/s)_{dn} = K_{dn}\left\{1.725+0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25} +0.01+0.50\left[N^{0.125}-1.0\right]\right\}(w/s)_o \tag{147}$$

Where

N_{zult} = ultimate positive load factor

DWG = basic flight design gross weight

S_w = gross wing planform area

S_{pnl} = planform area for each device segment

b_{pnl} = device segment span measured along forward device control line

C_{ave} = average device segment chord

$(t/c)_{ave}$ = aerodynamic thickness ratio at segment midspan

Fixed Trailing Edge Structure

Fixed trailing edge structure weight analysis is based on the same procedures as described for the fixed leading edge, except that processing of fixed structure incremental weights where control surface devices occur includes positive increments. These positive delta weights are added to the basic weight estimates to account for local structural provisions for the devices.

The basic statistical equation correlation factor, K_1 in the general Equation 131, is adjusted for fixed trailing structures by a coefficient that is sensitive to the maximum design dynamic pressure. The correction factor ΔK_q is determined as:

$$\Delta K_q = C_a\left[\left(\frac{Q_{max}}{Q_o}\right)^{C_b} - 1\right] \tag{148}$$

Where C_a and C_b are constants, currently assigned values of 1.0 and 0.70 for wing and 0.75 and 0.70 for horizontal and vertical tail surfaces, and

Q_o = reference dynamic pressure, 950 psf

Q_{max} = maximum dynamic pressure, psf

The estimation equations for $(w/s)_o$ and the final fixed trailing edge unit weights are listed in the following for wing, horizontal, and vertical tails:

1. Wing:

$$(w/s)_o = 0.0165 \left[\frac{0.35\ Q_{max}\ S_{te}}{b_{te}} \right] + 1.45 \tag{149}$$

$$(w/s)_w = K_w \left\{ 1.0 + \Delta K_q + 0.10 \left[\frac{0.10}{(t/c)_{ave}} \right]^{0.25} \right\} (w/s)_o \tag{150}$$

2. Horizontal tail:

$$(w/s)_o = 0.0145 \left[\frac{0.35\ Q_{max}\ S_{te}}{b_{te}} \right] + 1.35 \tag{151}$$

$$(w/s)_h = K_h \left\{ 1.0 + \Delta K_q + 0.10 \left[\frac{0.10}{(t/c)_{ave}} \right]^{0.25} \right\} (w/s)_o \tag{152}$$

3. Vertical tail:

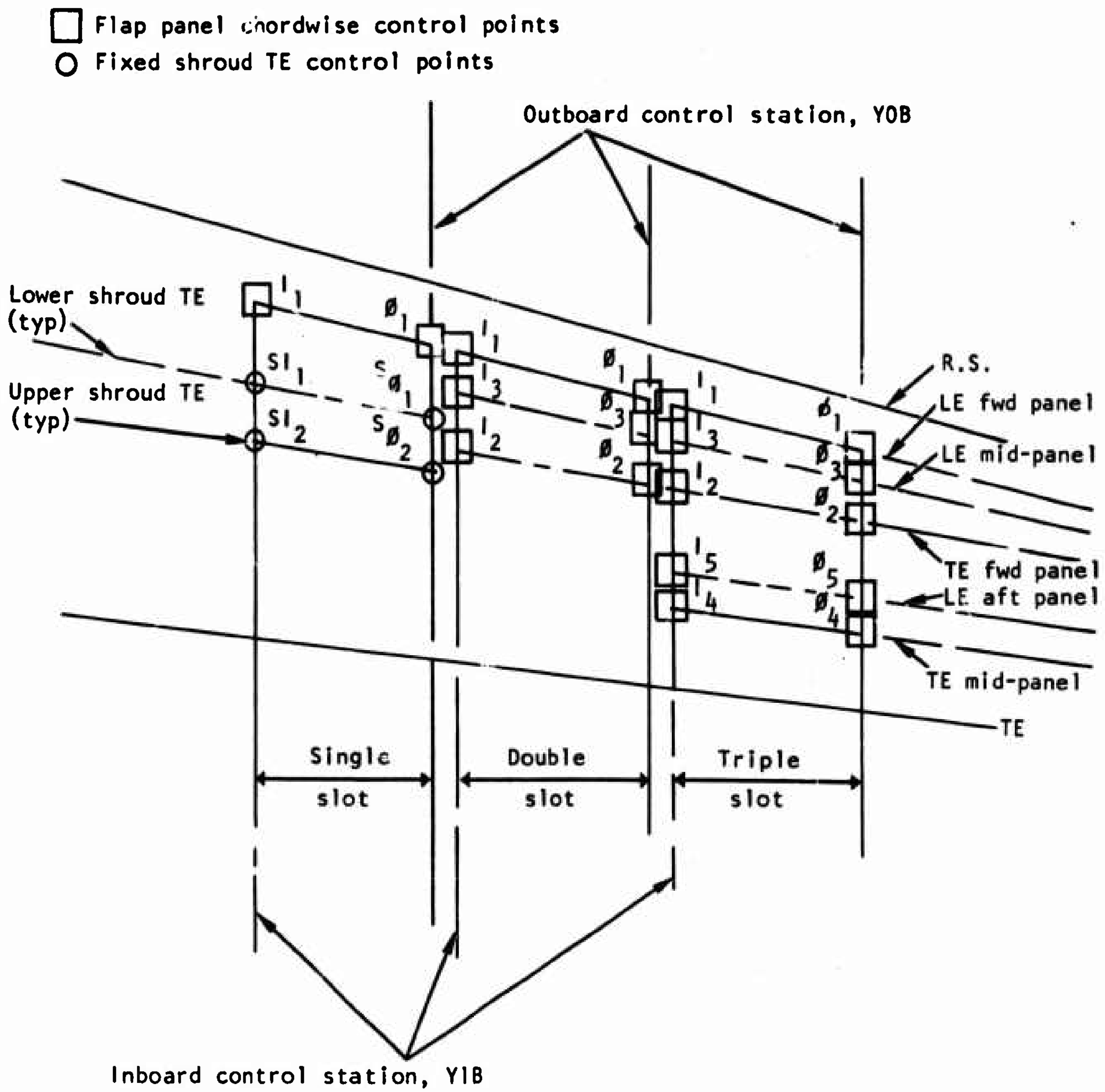
$$(w/s)_o = 0.0145 \left[\frac{0.35\ Q_{max}\ S_{te}}{b_{te}} \right] + 1.35 \tag{153}$$

$$(w/s)_v = K_v \left\{ 1.0 + \Delta K_q + 0.10 \left[\frac{0.10}{(t/c)_{ave}} \right]^{0.25} \right\} (w/s)_o \tag{154}$$

Trailing Edge Control Devices

Provisions are made for evaluation of up to six trailing edge control devices: 1 and 2 for spoilers; 3,4, 5 for flaps; and 6 for flap/aileron. For flap-type devices 3, 4, and 5 (plus 6 if flap type is ordered), one of four general types of flaps can be specified - simple, single-slotted, double-slotted, or triple slotted. Additional data are required for double- and triple-slotted flaps to describe relative sizes of the chordwise panels (Figure 47).

Control device 6 is internally treated as a general device, so that flap-type or ailerons for wings, elevators for horizontal tail, and rudders for vertical tails can be evaluated. Two additional data subsets are included for this device for elevators and rudders. The analysis routine checks indicator status for lifting surface type and device type to logically determine the type of analysis to be performed.



Schedule of required chordwise control point data

Flap ID	Flap type	$I_1,\varnothing_1$	$I_2,\varnothing_2$	$I_3,\varnothing_3$	$I_4,\varnothing_4$	$I_5,\varnothing_5$	Shroud control points $SI_1, S\varnothing_1$	$SI_2, S\varnothing_2$
0	Simple	X	-	-	-	-	Optional	Optional
1	Single-slotted	X	-	-	-	-	X	X
2	Double-slotted	X	X	X	-	-	X	X
3	Triple-slotted	X	X	X	X	X	X	X

Figure 47. Geometry description for trailing edge device No. 3, 4, and 5 - trailing edge flaps.

Estimated weights are distributed by the procedures discussed under "Lifting Surface Design Data," of this section. The estimation equations for trailing edge devices are:

1. Spoilers:

$$(w/s)_o = 0.008 \left[\frac{0.8\, Q_{max}\, S_{pnl}}{b_{pnl}}\right] + 1.95 \tag{155}$$

$$(w/s)_{sp} = K_{sp}\left\{1.0+0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25}+0.01+1.0\left[N^{0.125}-1\right]\right\}(w/s)_o \tag{156}$$

2. Trailing edge flaps:

$$(w/s)_o = 0.69\left[\frac{14.4\, Q_{max}\left(\frac{S_f}{b_f}\right)^2}{100\,(t/c)_{ave}}\right]^{0.25} \tag{157}$$

$$(w/s)_f = K_f\left\{K_{type}+0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25}+0.01+1.5\left[N^{0.125}-1\right]\right\}(w/s)_o \tag{158}$$

3. Ailerons:

$$(w/s)_o = \left\{0.01825\left[\frac{0.35\, Q_{max}\, S_a}{b_a}\right]+1.55\right\}+\left\{0.50\left[0.35\,(Q_{max})^{0.25}\right]\right\} \tag{159}$$

$$(w/s)_a = K_a\left\{1.0+0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25}+0.01+0.10\left[N^{0.125}-1\right]\right\}(w/s)_o \tag{160}$$

4. Elevators:

$$(w/s)_o = 0.773\left[\frac{0.35\, Q_{max}\cdot S_e}{b_e}\right]^{0.3069} \tag{161}$$

$$(w/s)_e = K_e\left\{1.40+0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25}+0.01+0.10\left[N^{0.125}-1\right]\right\}(w/s)_o \tag{162}$$

5. Rudders:

$$(w/s)_o = 0.02442\left[\frac{0.35\ Q_{max}\ S_r}{b_r}\right] + 1.35027 \tag{163}$$

$$(w/s)_r = K_r\left\{1.50+0.10\left[\frac{0.10}{(t/c)_{ave}}\right]^{0.25}+0.01+0.10\left[N^{0.125}-1\right]\right\}(w/s)_o \tag{164}$$

The K_{type} factor in Equation 158 is selected from a table of factors based on the type of flap specified. Table 17 shows the values for K_{type} along with the indicator control word values.

TABLE 17. FLAP-TYPE INDICATOR AND CORRELATION COEFFICIENTS

Flap Type	Indicator Value	Correlation Coefficient
Simple	0	1.000
Single-slotted	1	1.250
Double-slotted	2	1.500
Triple-slotted	3	1.750

The flap segment area, S_f, found in Equation 157, is the sum of all chordwise panel areas. Thus, for triple-slotted flaps, actual planform areas are computed for each of the three chordwise panels from the input data specifications (Figure 47). The value of b_f is based on the swept distance along the forward leading edge of each flap segment.

BASIC MODULE OUTPUT

The weight analysis routines derive estimated weights of lifting surface components in detail so that AN 9103-D, "Group Weight Statement," information can be prepared from the results. The estimates are ordered for (1) output by the output module of SWEEP in vehicle analysis weight statement format and (2) output by the output data print routine of the wing and empennage module. Figure 48 is the weight summary printed for each surface analyzed. Figures 49 and 50 are weight summary details for the torque box structures printed under optional output control. Detail pivot structure weight estimates shown in Figure 48 and the torque box summary in Figure 50 are printed only if variable-sweep wings are evaluated.

The format used to summarize torque box component weights (Figures 49 and 50) are tailored for multirib stringer designs. The same format and headings are used for the other three construction types - multispar plate, multispar honeycomb panels, and full-depth honeycomb sandwich. The format and headings are also the same for advanced composite designs. Weights for the various elements that make up these torque boxes are grouped and assigned to one of the applicable line items on the summary page. Table 18 defines those items that are grouped. Protective finish weights for advanced composite front and rear spar webs are included in the web weights for the spars. The honeycomb core and bond weights are also added to the spar webs weights if the honeycomb panel construction option is selected for the front or rear spar design.

CASE 2 WEIGHT SUMMARY. ** PRTD **

-***-TOTAL WING STIFFENED SKIN/MULTI-RIB-***-

SUPERCRITICAL WING SW=2100, AR=10.6, T/C=.14, TR=.35, DGW=421K, TOW=395K N1

H S GRAPHITE SKIN-STRINGER CONSTRUCTION

-****-TOTAL WEIGHT SUMMARY-****-

	WEIGHT--LB/AV			*UNIT WEIGHT--LB/SF*			*C.G.--BP*			*C.G.--FS*			*AREA*
	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	SF/AV
TOTAL	0.0	24375.1	0.0	0.0	11.61	0.0	0.0	418.8	0.0	0.0	1035.7	0.0	2100.0
O-PNL	0.0	16459.0	0.0	0.0	10.49	0.0	0.0	418.8	0.0	0.0	1035.7	0.0	1568.6
C-SEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
PIVOT	0.0	7916.1	0.0				0.0	145.0	0.0	0.0	969.0	0.0	

-**-OUTER PANEL COMPONENTS-**-

/T-BOX/	0.0	9354.6	0.0	0.0	15.00	0.0	0.0	378.0	0.0	0.0	1019.7	0.0	623.5
/L.E. /	0.0	2765.8	0.0	0.0	12.24	0.0	0.0	480.0	0.0	0.0	992.7	0.0	226.0
/T.E. /	0.0	4165.4	0.0	0.0	6.34	0.0	0.0	458.7	0.0	0.0	1097.6	0.0	657.2
/TIP /	0.0	92.4	0.0	0.0	1.30	0.0	0.0	864.1	0.0	0.0	1130.6	0.0	71.0
/MISC./	0.0	80.8	0.0	0.0	0.05	0.0	0.0	378.0	0.0	0.0	1019.7	0.0	1568.6
(+V.F.)	0.0	0.0	0.0										
(+FTG)	0.0	0.0	0.0										

-**-PIVOT SUMMARY-**-

DEL-PVT	0.0	8129.1	0.0
DEL-BOX	0.0	213.1	0.0
DEL-CS	0.0	0.0	0.0

-**-NOMINAL WING BOX SUMMARY-**-

T-BOX	0.0	9141.5	0.0	0.0	14.66	0.0	623.5
C-SEC	0.0	0.0	0.0	0.0	0.0	0.0	1.0
+V.F.	0.0	0.0	0.0				

-**-DESIGN DATA-**-

PIVOT//MISC.	0.0	7916.1	0.0	0.0	78.4	0.0
WT(IB)//WT(OB)	0.0	3082.2	0.0	0.0	2075.5	0.0
RB(IB)//W(PIN)	0.0	910.3	0.0	0.0	1769.7	0.0
P(ID)//P(OD)	0.0	16.000	0.0	0.0	12.478	0.0
Y-BP//W-ST(IB)	0.0	121.000	0.0	0.0	70.213	0.0
Y-BP//W-ST(OB)	0.0	169.000	0.0	0.0	93.469	0.0
MOM(P)//FBR(P)	0.0	146.338	0.0	0.0	128.633	0.0

TOGW(1)= 0.0 TOGW(2)= 431000.0 TOGW(3)= 0.0 +NZ= 2.000 +NZG= 0.0 FL(TOT)= 45891.5 MATL NO= 14

DGW(1)= 0.0 DGW(2)= 430998.9 DGW(3)= 0.0 -NZ= 1.000 -NZG= 0.0 FL(DES)= 45890.3 YCP= 429.1

Figure 48. Lifting surface component weight summary.

CASE 2 -***-NOMINAL TORQUE-BOX DETAIL WEIGHTS-***- ** PRTD - IP(37) **

	-**-TOTAL SURFACE-**-			-**-OUTER PANEL-**-			-**-CENTER-SECTION-**-		
	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)
TORQUE-BOX	0.0	9141.5	0.0	0.0	9141.5	0.0	0.0	0.0	0.0
UPPER COVER	0.0	3272.2	0.0	0.0	3272.2	0.0	0.0	0.0	0.0
SKINS	0.0	1103.3	0.0	0.0	1103.3	0.0	0.0	0.0	0.0
STRG.	0.0	1568.8	0.0	0.0	1568.8	0.0	0.0	0.0	0.0
MISC. SK.	0.0	600.1	0.0	0.0	600.1	0.0	0.0	0.0	0.0
LOWER COVER	0.0	2565.4	0.0	0.0	2565.4	0.0	0.0	0.0	0.0
SKINS	0.0	817.2	0.0	0.0	817.2	0.0	0.0	0.0	0.0
STRG.	0.0	1137.2	0.0	0.0	1137.2	0.0	0.0	0.0	0.0
MISC. SK.	0.0	611.0	0.0	0.0	611.0	0.0	0.0	0.0	0.0
RIBS	0.0	1023.6	0.0	0.0	1023.6	0.0	0.0	0.0	0.0
INTERM.	0.0	451.0	0.0	0.0	451.0	0.0	0.0	0.0	0.0
BULKHEADS	0.0	299.3	0.0	0.0	299.3	0.0	0.0	0.0	0.0
RT/C-L	0.0	273.4	0.0	0.0	273.4	0.0	0.0	0.0	0.0
FRONT SPAR	0.0	867.7	0.0	0.0	867.7	0.0	0.0	0.0	0.0
CAPS	0.0	179.1	0.0	0.0	179.1	0.0	0.0	0.0	0.0
WEB	0.0	688.5	0.0	0.0	688.5	0.0	0.0	0.0	0.0
REAR SPAR	0.0	905.3	0.0	0.0	905.3	0.0	0.0	0.0	0.0
CAPS	0.0	182.0	0.0	0.0	182.0	0.0	0.0	0.0	0.0
WEB	0.0	723.3	0.0	0.0	723.3	0.0	0.0	0.0	0.0
MISC. ATT.	0.0	507.4	0.0	0.0	507.4	0.0	0.0	0.0	0.0
STORE FTG.	0.0	0.0	0.0	0.0	0.0	0.0			

-**-LEADING EDGE-**-			
FIXED STR	0.0	939.3	0.0
DEV. NO. 1	0.0	1001.1	0.0
DEV. NO. 2	0.0	925.4	0.0
DEV. NO. 3	0.0	0.0	0.0

-**-TRAILING EDGE-**-			
FIXED STR	0.0	1245.9	0.0
T.E. FLAPS	0.0	2465.6	0.0
SPOILERS	0.0	454.0	0.0
AILERONS	0.0	0.0	0.0

Figure 49. Torque-box weight summary, page 1.

CASE 2 -***-DETAIL WEIGHTS--WING BOX LESS PIVOT STRUCT.-***- ** PRTD - IP(37) **

	-**-TOTAL SURFACE-**-			-**-OUTER PANEL-**-			-**-CENTER-SECTION-**-		
	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)	GW(1)	GW(2)	GW(3)
TORQUE-BOX	0.0	9354.6	0.0	0.0	9354.6	0.0	0.0	0.0	0.0
UPPER COVER	0.0	3318.5	0.0	0.0	3318.5	0.0	0.0	0.0	0.0
SKINS	0.0	1070.6	0.0	0.0	1070.6	0.0	0.0	0.0	0.0
STRG.	0.0	1531.4	0.0	0.0	1531.4	0.0	0.0	0.0	0.0
MISC. SK.	0.0	716.6	0.0	0.0	716.6	0.0	0.0	0.0	0.0
LOWER COVER	0.0	2635.0	0.0	0.0	2635.0	0.0	0.0	0.0	0.0
SKINS	0.0	791.6	0.0	0.0	791.6	0.0	0.0	0.0	0.0
STRG.	0.0	1108.6	0.0	0.0	1108.6	0.0	0.0	0.0	0.0
MISC. SK.	0.0	734.8	0.0	0.0	734.8	0.0	0.0	0.0	0.0
RIBS	0.0	1107.2	0.0	0.0	1107.2	0.0	0.0	0.0	0.0
INTERM.	0.0	454.3	0.0	0.0	454.3	0.0	0.0	0.0	0.0
BULKHEADS	0.0	381.5	0.0	0.0	381.5	0.0	0.0	0.0	0.0
RT/C-L	0.0	271.4	0.0	0.0	271.4	0.0	0.0	0.0	0.0
FRONT SPAR	0.0	844.2	0.0	0.0	844.2	0.0	0.0	0.0	0.0
CAPS	0.0	175.5	0.0	0.0	175.5	0.0	0.0	0.0	0.0
WEB	0.0	668.7	0.0	0.0	668.7	0.0	0.0	0.0	0.0
REAR SPAR	0.0	881.7	0.0	0.0	881.7	0.0	0.0	0.0	0.0
CAPS	0.0	178.3	0.0	0.0	178.3	0.0	0.0	0.0	0.0
WEB	0.0	703.3	0.0	0.0	703.3	0.0	0.0	0.0	0.0
MISC. ATT.	0.0	568.0	0.0	0.0	568.0	0.0	0.0	0.0	0.0
STORE FTG.	0.0	0.0	0.0	0.0	0.0	0.0			

Figure 50. Torque-box weight summary, page 2, pivot type.

TABLE 18. TORQUE-BOX SUMMARY PAGE LINE ITEM DEFINITIONS

Summary Page Line Item	Construction Type: Multirib Skin-stringer Covers	Multispar Plate Covers	Multispar Honeycomb Panel Covers	Full-Depth Honeycomb Sandwich
SKINS	a	a	b	b
STRG.	c	d	d,e	f
MISC. SK.	g,i,j	g,i,j	f,g,h,i,j	g,i
INTERM.	k,m,n	l,m,n	l,m,n	h
MISC. ATT.	o,p,q	o,p,q	o,p,q	p,q

Code Definitions:

a = cover skin, including forward and aft overhang
b = face sheets, including forward and aft overhang
c = stringers
d = intermediate spar caps
e = honeycomb panel inserts at intermediate spars
f = bond weight, face sheets to core
g = skin pads at intermediate ribs or spars, front and rear spars, tip and root ribs, bulkheads and splices (includes fillers at ribs and spars for advanced composite option)
h = core
i = exterior flame spray protection for advanced composite skins
j = interior seal and/or protective finish for advanced composite skins
k = intermediate ribs (caps and webs)
l = intermediate spar webs
m = protective finish and/or sealant for advanced composite webs
n = core and bond for honeycomb panel webs (advanced composite structure option only)
o = miscellaneous attachments for intermediate ribs or spars
p = cover-to-support structure attachments
q = splice fasteners

DESIGN DATA GENERATION OPTION

GENERAL DESCRIPTION

Evaluation of the dynamic characteristics of lifting surfaces, particularly high-performance wing with thin, highly swept, high-aspect-ratio planforms, are an important part of the preliminary design cycle. The analytical programs used to evaluate airloads due to wing flexibility and for optimization of the wing torque box to satisfy flutter criteria require engineering descriptions of the physical characteristics of the wing in terms of geometry, stiffness, and mass properties. Much of these data are developed by the wing and empennage module of SWEEP as part of the synthesis/weight analysis of lifting surfaces.

The data generation option of this module produces, as output, the preliminary data necessary for flexibility and/or flutter analysis. Most of the design data required by the stand-alone flexible loads analysis program and the flutter optimization programs can be obtained as module output, special punched output, and/or printed output.

This SWEEP option for design data generation was developed to be used during the iterative design cycle in which the effects of wing flutter stiffness requirements and wing flexibility are optimized for efficient spanwise distribution of torque box material. In this study phase, stand-alone versions of SWEEP, flutter optimization, and flexible loads programs would be used as illustrated in Figure 51. Each program is set up to evaluate the configuration and, as output, to produce design information as printed and/or punch output. Evaluation of these results can then be made by responsible engineering specialists before use as input data for the other programs.

PROGRAM DESCRIPTION

The data generation option of the wing and empennage module is designed primarily to provide mass properties and structural design data for the flutter optimization and flexible loads analysis programs described in Volumes X and XI. Analysis controls and evaluation procedures are programmed in the output overlay, overlay (17,0). Additional mass properties procedures are included in overlays (14,0) and (15,0), and additional data processing is included in the torque box synthesis control routines of overlays (9,0) and (18,0) to provide the necessary inputs to overlay (17,0) routines.

Subroutines WVFDD and WFLDD are the data generation routines programmed for this option. Special subroutines TBFWI, TPINT, PINTØ, and CTØT are used

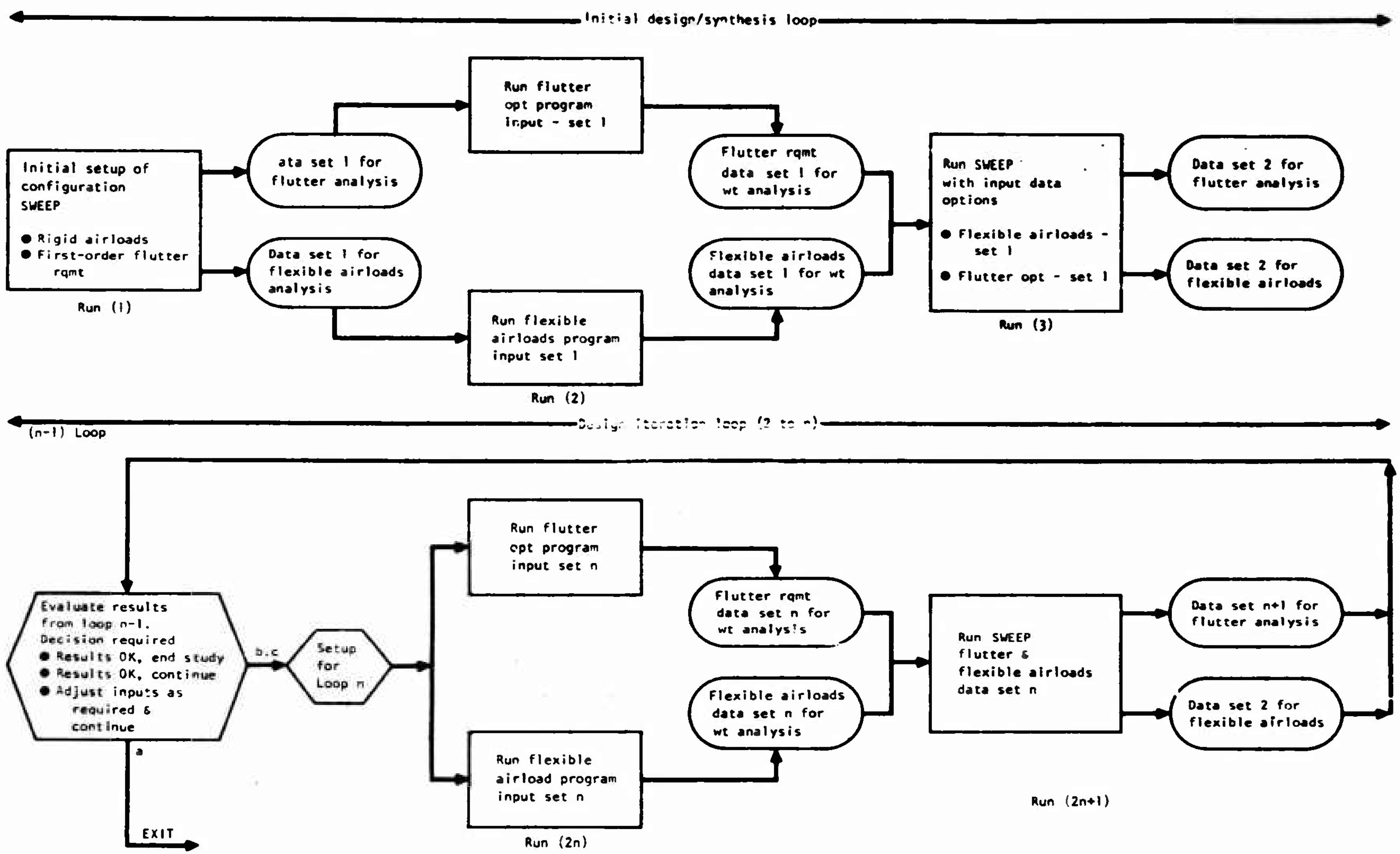


Figure 51. Flutter, flexible airloads, weight optimization design loop (stand-alone programs).

by these subroutines. WVFDD provides the output data set for the flutter optimization program, using PINTØ to print and punch the results in the data card format required. WFLDD creates the data set for the flexible loads program. Output information consists of pertinent vehicle design criteria, wing geometry, torque box bending and torsional stiffness, and strip mass distributions.

The integration of mass properties distributions are made in overlays (14,0), (15,0), and (17,0). Computations in overlays (14,0) and (15,0) result in mass properties estimates made for leading edge and trailing edge structures, torque box fuel and contents, and externally mounted concentrated mass items. Integrations of weight and inertia distributions are always made for both flexible loads and flutter in conjunction with the integrations performed for deadweight loads evaluations in the structural/weight analysis system.

In overlay (17,0), the weight and inertia distributions of the final estimated torque box weights are evaluated and combined with the previously calculated data. The summation of loads and flutter system data is performed by separate subprograms written to process the required data for output.

MASS PROPERTIES AND DESIGN DATA PROCESSING REQUIREMENTS

Mass properties, structural design, and geometry data are required in different reference systems, for different sets of control stations, strip widths, and strip orientations. Each program requires data which are evaluated at predetermined control stations and referenced to one of the two basic lifting surfaces coordinate reference systems. Data describing the mass characteristics for all items contained in the moldline of the exposed wing are processed as distributed masses - 10 equal-width aerodynamic strips for the flexible loads analysis program (Figure 52) and 11 structural system strips for the flutter optimization program (Figure 53).

Mass properties data must also be evaluated separately for each program, since the flutter design point and vehicle design loading may not be the same as for the critical design loads condition. Furthermore, the critical design point and vehicle loading resulting from the flexible loads analysis may also be different from that resulting from the rigid loads analysis. Thus, evaluations for mass properties of wing fuel and externally mounted expendable items are evaluated individually for each program, based on user specifications defined through control data in the input data set.

Mass properties summation logic in each system is designed to compute for output the total mass distribution for a specified vehicle loading condition. Remaining wing fuel for the output design data is determined from a fuel usage schedule array in the input data set. Separate data sets are provided to define fuel status for flexible loads design loading and flutter design

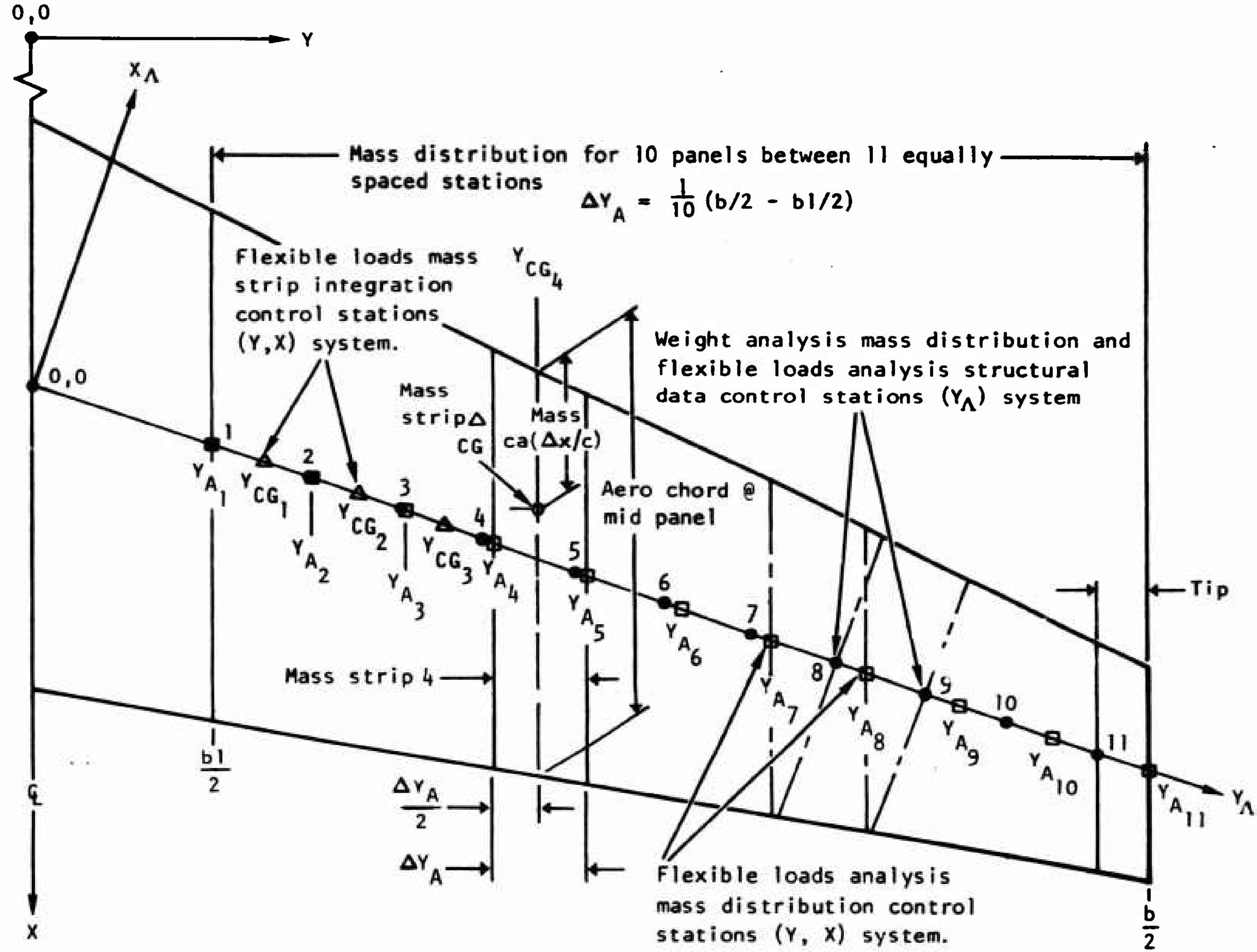


Figure 52. Flexible loads analysis mass distribution and integration reference system.

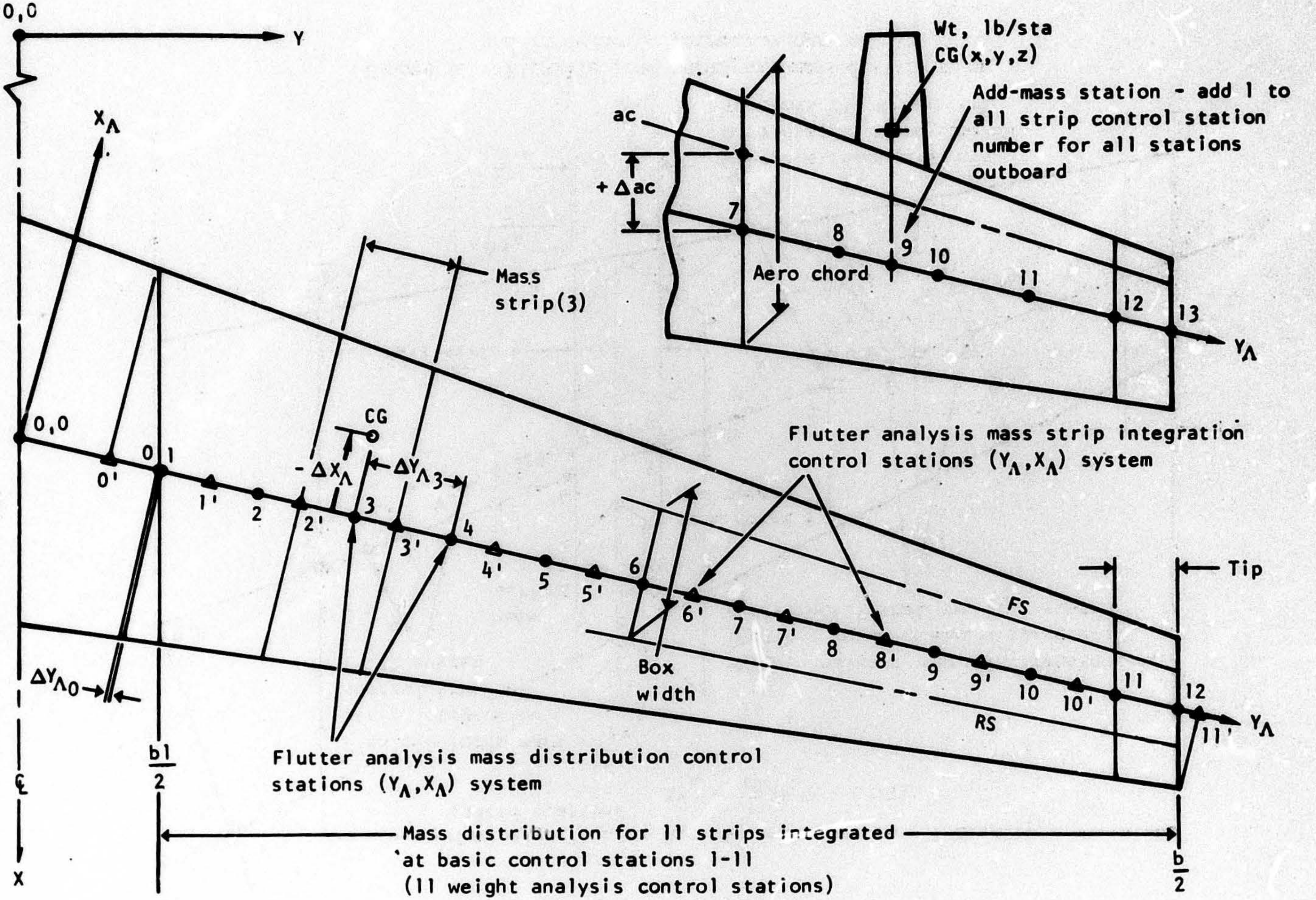


Figure 53. Flutter optimization analysis mass distribution and integration reference system.

loading. Estimated full-capacity fuel mass properties data for each fuel cell are scaled to the desired fuel level.

Provisions are made to process two sets of externally mounted concentrated mass items so that effects of store/external fuel configurations can be evaluated by the flexible loads and flutter optimization programs. Loading status schedule similar to that for fuel usage is provided.

The structure temperatures for flexible loads analysis and the critical flutter conditions may differ from the design temperature for torque box strength requirements. Thus, the stiffness levels resulting from the strength analysis must be adjusted to account for the effect of temperatures on the structural material. In the analysis of metallic designs, it is assumed that the material modulus of elasticity, E, and modulus of rigidity, G, are constant over the complete span. Adjustments of stiffness levels for temperature differences are made by linear scaling of computed EI and GJ. The scaling factor is the ratio of E and G values, at the new design temperature to the base values. Stiffness levels of metallic designs for the two types of output data sets are controlled by input of required values of design E's and G's or factors for each to be applied to the strength design EI and GJ.

Stiffness levels of advanced composite torque boxes are expressed in terms of EI and GJ. However, the E and G parameters cannot be assumed to be constant over the span. Also, the equivalent values of E and G at any section is dependent upon number and ply orientation for all members of the torque box. Thus, the stiffness analysis routines for advanced composite torque boxes are programmed to compute EI and GJ with at temperature material properties for each set required. The input data set for advanced composite analysis includes provisions for specifying the desired design temperatures to be used.

STRUCTURAL SYNTHESIS/WEIGHT ANALYSIS REFERENCE SYSTEM

During the structural synthesis/weight analysis of lifting surfaces, geometry, design loads, and structural design requirements are evaluated at 11 control stations, based on the (Y_Λ, X_Λ) structural reference system (Figure 54). Torque box structures are synthesized at these stations. Unit spanwise weights are determined; then estimated weights are calculated by integration between these stations. Bending stiffness, EI, and torsional stiffness, GJ, are computed from synthesis data at each station. These synthesized data provide the necessary distribution data for computing the required data for the flutter optimization and flexible loads analysis programs.

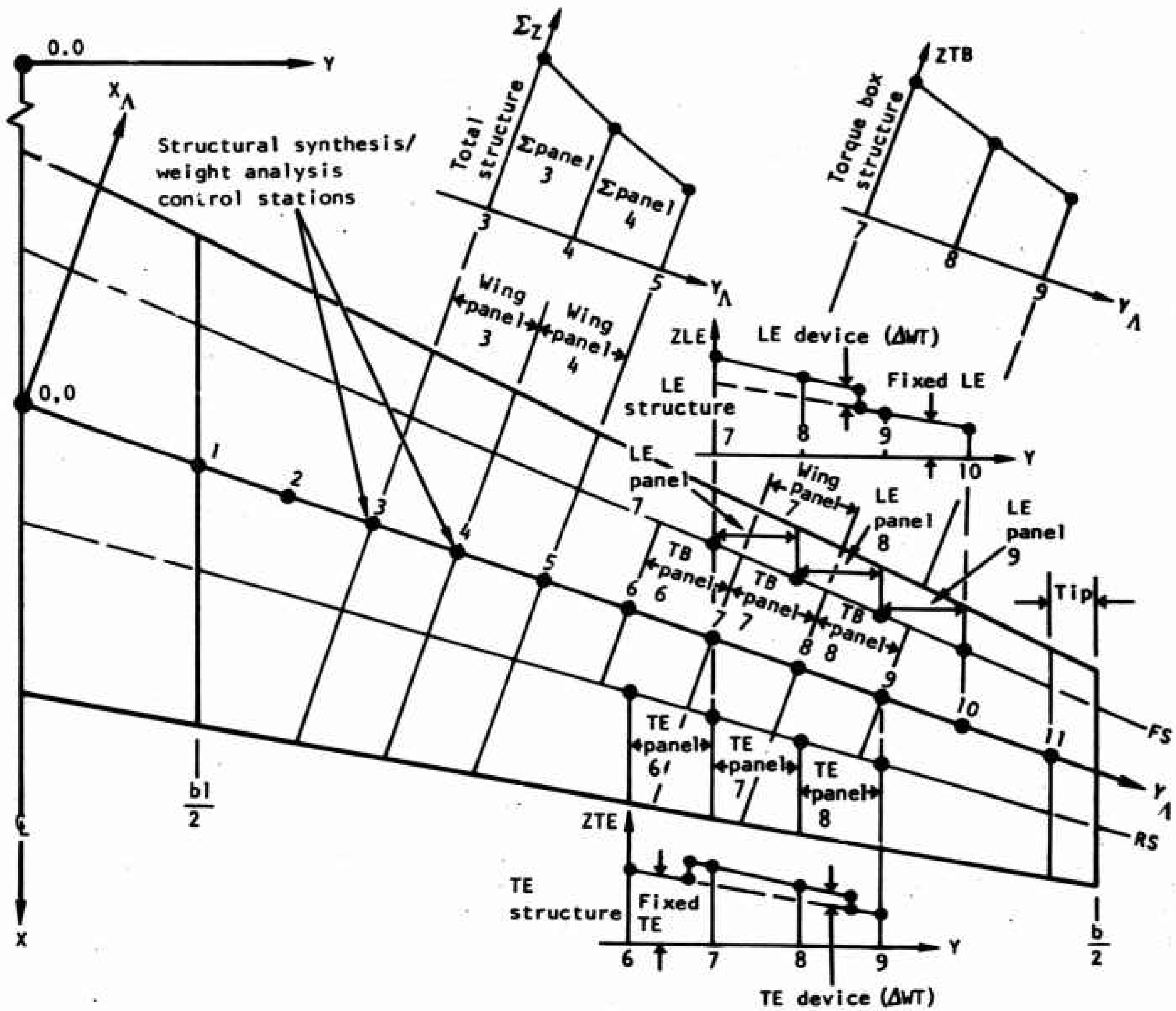


Figure 54. Structural synthesis/weight analysis reference system and weight integration.

Mass distribution surfaces are defined for each wing structure component and content items. The evaluation procedure is based on numerical integration of mass properties for rectangular mass elements with uniform density. Properties are evaluated for individual grids of a finite grid pattern defined for each component (Figure 55). The densities are based on the weight surface ordinate at the grid centroid determined from spanwise weight per inch values that are distributed chordwise. The numerical summation of each grid element is governed by the relationship of grid centroid coordinates to the control station coordinates and strip boundaries.

DATA FOR FLEXIBLE LOADS ANALYSIS PROGRAM

Two sets of reference systems are used for the development of data necessary for the flexible loads analysis program. Mass properties data are evaluated for 10 exposed wing panel strips, with boundaries defined by 11 equally spaced aerodynamic cuts (Figure 52). Integration of the weight distribution surface is based on aerodynamic reference system coordinates. Total panel mass and chordwise centroids are summed to mass distribution control stations at panel midpoints on the structural reference axis. The strip mass centroid is then ordered for output as the chord distance from the centroid to the leading edge at the mass control station.

Concentrated mass items are included as part of distributed strip data. Location of each concentrated mass item (up to seven items may be described in the input data set) is determined relative to the mass integration control stations. The mass items are assumed to affect the two control stations that straddle the mass coordinate point on the reference axis; thus, these weights are beamed to the stations, using simple beam static equations for determining reactions. Mass items which are adjusted for design condition status are adjusted before processing to the proper strip control stations.

Structural stiffness data, EI and GJ, are based on analysis control stations resulting from the structural synthesis/weight analysis. Structural station values and the EI and GJ estimates resulting from the torque box synthesis are processed into 12 control station sets for output. A control station is added between analysis control stations 1 and 2 to provide EI and GJ values close to the root station to allow the curve fit/curve evaluation procedure of the flexible loads analysis program to properly approximate inboard spanwise stiffness distributions. The added station is at a station increment based on the smaller of the two values: (1) one-fourth of the distance between analysis stations 1 and 2, and (2) one-tenth of the distance between station 1 and the centerline, along the structural reference axis.

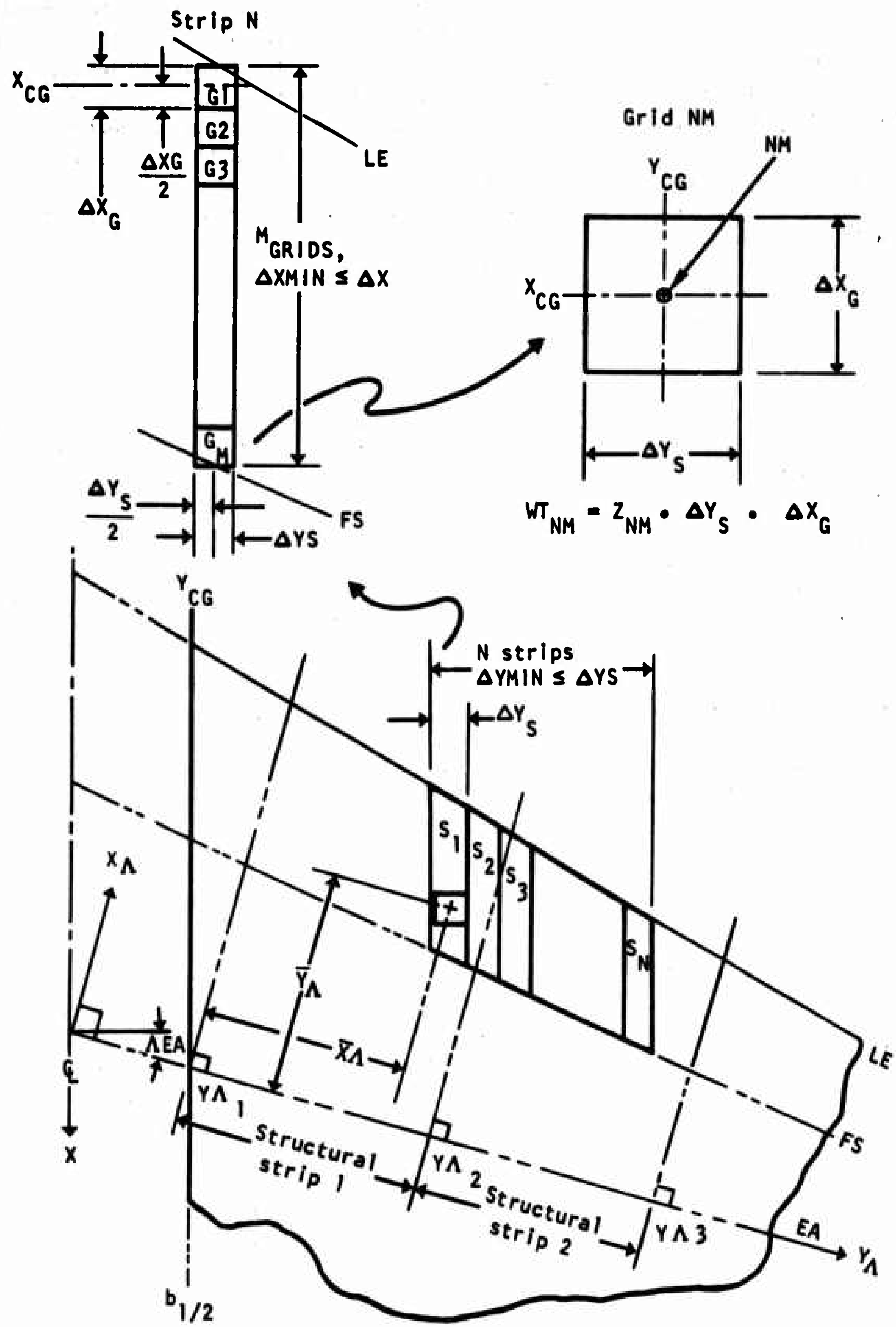


Figure 55. Mass properties integration grid system.

Two data decks are output for the flexible loads analysis program, with all punched data formatted for read by subprogram DECRD. The first data set consists of BC array data calculated by the data management module of SWEEP for use by the airloads module. The flexible loads analysis program uses the same data array. BC array definitions can be found in Volume II, "Program Integration and Data Management Module." The second data set includes calculated design and mass properties ordered for read into the BF array of the program.

DATA FOR FLUTTER OPTIMIZATION PROGRAM

The reference coordinate system for flutter optimization analysis is the same as the structural reference coordinate system. All mass properties and structural design data are computed for strips normal to, and at stations on, the spanwise reference axis, Y_{Λ}. The structural analysis control stations are used as control stations for the flutter optimization analysis, and computed data are ordered in the array format required by that program. Figure 53 shows the control numbering used for determining the data requirements. Thirteen flutter optimization control stations are normally created - 11 for strip data, plus an inboard and an outboard control station required by the flutter program. Two additional control stations may be added, for a maximum of 15 stations. These added stations are created for each of two externally mounted masses on the wing at the flutter design condition, if these masses are specified in the input data set for analysis.

The presence of add-mass items requires that control station numbers for stations outboard of the mass be increased by one, and associated data processed to conform to the revised station numbers. Thus, for the inserted sketch in Figure 52, the initial control stations 9 to 12 are assigned control station numbers 10 to 13, and the station at the add-mass coordinate on the reference axis is assigned station No. 9.

Two sets of add-mass data are prepared for output for flutter analysis, based on data subset specifications in the input data set describing these masses. Elements of a matrix describing the mass are determined and included as special data sets for output, along with associated stiffness, geometry, and required control indicators. These adjustments are made by subroutine WVFDD so that design data are ordered properly for compatibility with the control stations and the data read routine of the flutter program.

Concentrated mass items which are not processed as add-mass items for the flutter optimization program are integrated with the mass properties of the strip in which the mass Y coordinate intersects the structural reference axis (same as shown for the add-mass item in Figure 53).

Mass properties data for distributed masses are determined for 11 strips. The strips are associated with the 11 weight analysis stations and are bounded by the structural stations at the centroids of the 10 trapezoidal panels occurring between the 11 analysis stations. The mass distribution surface is integrated between these boundaries to the control stations based on structural reference system coordinates. Strip mass, mass centroid distance from the reference axis, and pitch and roll inertias about the mass centroid (structural reference system) are computed for each strip and ordered for output.

Other data ordered for output include:

1. EI and GJ at the control stations (lb-in^2.)

2. Structural box width and average depth (in.)

3. Aerodynamic wing chord at the control station (in.)

4. Incremental structural span distance to the next outboard control station (in.)

5. Change in the sweep of the reference axis at the control station, if any (deg)

6. Node control indicators for each control station

7. Distance from the control station to the local aerodynamic center of pressure, assumed to be at the 25-percent chord line (in.)

8. Local slope of the lift curve, assumed to have the value equal to $2\pi\cos(\Lambda_{25c})$, per radian

EI and GJ values at add-mass stations created from the input data set specifications are based on a three-point parabolic fit/interpolation procedure. Torque box geometry at these stations is based on straight-line interpolation for width and depth.

General configuration-oriented design data are also required for output. These data can be specified in the input data set for inclusion in the output data set or, if the data cell is set to zero, the program will use internally generated data for output. These include:

1. E, modulus of elasticity for the torque box material (psi)

2. G, modulus of rigidity for the torque-box material (psi)

3. ρ, density of the torque box material (lb/cu in.)

4. Density of air at the critical flutter speed and altitude for which the output data set is being created. This critical point, in general, is assumed to be at maximum limit speed, V_L, at sea level. The value of the critical flutter speed is determined by applying a factor of safety to this speed - 1.15 for military designs and 1.20 for commercial design (lb/cu in.).

5. Buttock line station of the root station (in.)

6. Required flutter speed, defined by item 4 (kn)

7. Vehicle less wing and contents mass properties data:

   a. Weight (lb/side)

   b. Distance to the mass centroid of item a. from the fuselage station of the root control station (in.) positive if the mass is aft of the root station

   c. Pitch moment of inertia of item a. about the mass centroid ($lb\text{-}in.^2$)

   d. Roll moment of inertia of item a. about the vehicle centerline ($lb\text{-}in.^2$)